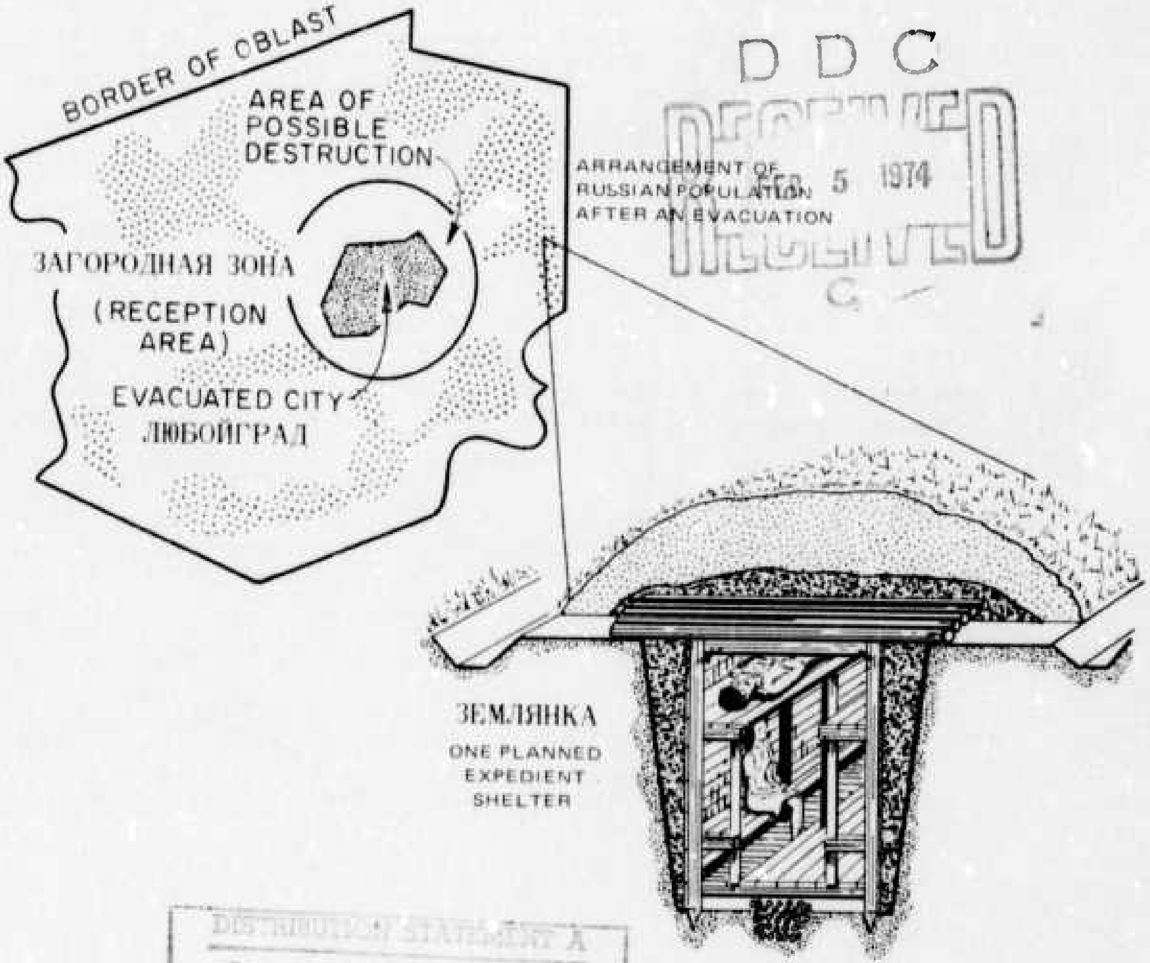
ORNL-TR-2793

CIVIL DEFENSE

ГРАЖДАНСКАЯ ОБОРОНА

MOSCOW 1970



PREPARED BY OAK RIDGE NATIONAL LABORATORY

SUPPORTED BY UNITED STATES ATOMIC ENERGY COMMISSION

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

ORNL-TR-2793
Distribution Category UC-41

CIVIL DEFENSE

(Grazhdanskaya Oborona)

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Publishing House for Higher Education

(Vysshaya Shkola)

Second Edition, Moscow (1970), 500,000 copies

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December 1973

Translation sponsored jointly by the Defense Advanced Research Projects Agency and the U.S. Atomic Energy Commission under contract with the Union Carbide Corporation, Interagency Agreement DARPA No. 2297, October 1972.

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*This Table of Contents is a somewhat extended version of the Soviet one.

U.S. Editors' Preface

THE IMPORTANCE OF CIVIL DEFENSE IN THE SOVIET UNION

There is considerable evidence that civil defense in the Soviet Union — in contrast to civil defense in the United States — is a major component of national defense capabilities. In support of this statement we cite the following examples:

1. It is endorsed by Marshal A. Grechko, Defense Minister of the USSR and Politburo member.[1]
2. With the appointment of its present head, A. T. Altunin, in 1972, the position of Civil Defense Chief of the USSR was upgraded to that of a deputy minister of defense.[2]
3. Its strengthening was called for by L. I. Brezhnev at the 23rd Party Congress.[3]
4. Its importance as a means of saving the worker, on whom production (and thus the state itself) depends, was recognized by Lenin (p. 45).
5. Civil defense instruction for the entire population is required by law.[4]

OVERALL OBJECTIVES OF SOVIET CIVIL DEFENSE

Essentially, the objectives of the Soviet civil defense program are fourfold:

1. to protect the population from weapons of mass destruction;
2. to increase the stability of vital industries so that they could continue to function in wartime;
3. to protect crops and livestock from nuclear, chemical, and biological weapons;
4. to perform rescue and emergency-reclamation operations in stricken areas.

WHY WE HAVE TRANSLATED THIS SOVIET CIVIL DEFENSE HANDBOOK

In 1971 we published a translation[5] of *Grazhdanskaya Oborona (Civil Defense)* (Moscow, 1969), a Russian handbook which deals primarily with the protection of people, livestock, and crops from the effects of nuclear, chemical, and biological weapons. This newer (1970) handbook, also entitled *Grazhdanskaya Oborona (Civil Defense)*, is concerned not only with protecting the population, but also with protecting and strengthening essential industries so that a larger fraction of them could continue production after a nuclear attack. Performing rescue and emergency-repair work in stricken areas is likewise given increased emphasis. Moreover, the procedures for evacuation and dispersal, discussed in the 1969 handbook, are described in even greater detail in this newer one.

There is little question that the Soviet Union has the most comprehensive and detailed evacuation-dispersal plan in the world. We believe that the description of this plan in the handbook, together with Soviet plans to protect industries and perform rescue-repair work, make *Civil Defense* (1970) a valuable resource to all interested in the U.S. civil defense program. We believe that this handbook would also be of interest to active defense planners and researchers, because not only does the present Soviet CD program reflect the Soviet theories on the nature of possible future threats to them, but also reveals, by implication, the kinds of threats that they themselves could present in the event of an escalating crisis.

PROTECTING THE POPULATION

The central feature of the Soviet civil defense program is its comprehensive dispersal-evacuation plan. According to this plan, the personnel, both operational and supervisory, of essential industries are to be

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dispersed with their families to small towns, villages, and collective farms outside the anticipated blast areas around the cities and other nuclear targets. The zones in which these towns, villages, and farms lie are selected on the basis of being far enough away from target areas to be safe from the blast effects of nuclear weapons, but near enough that the workers and staff members could commute to work inside anticipated blast areas – a round-trip travel distance of no longer than 4 to 5 hr (p. 46). Retired people, educators, and workers in nonessential industries, and sometimes light industries as well, would be *evacuated* from large cities to rural areas, where they would remain until the crisis subsided. Both evacuated and dispersed persons would be quartered with the rural residents and would be protected from fallout in high-protection-factor expedient shelters, which they would help their rural hosts to construct or improve.

According to estimates in chapter 3 of this manual, "...in a nuclear rocket attack the losses to the population in a large unprotected city may constitute 90% ... whereas in case of a timely and complete dispersal and evacuation ... the losses may be reduced to several percent of the total population" (p. 46).

The employees subject to dispersal would go on a two-shift system and continue production during the crisis, with blast and fallout shelters provided for the on-duty shift at its place of work. Should attack occur, the off-duty shift would then advance in formations to its stricken facility to perform rescue and emergency-repair operations or, if its own facility were undamaged, to a damaged neighboring one. Employees are trained for this purpose at their place of work and organized into reconnaissance teams, fire-fighting brigades, rescue units, repair crews, etc.

Thus, saving people is the primary goal of the Soviet civil defense program. The Soviet method of achieving it is to evacuate and disperse the urban population to rural areas, safeguard the people and their food supply, and rescue the injured.

INCREASING THE OPERATIONAL STABILITY OF VITAL INDUSTRIES

Second only to protecting people in the Soviet civil defense scheme is increasing the operational stability of vital industries and maintaining production. It is the purpose of this handbook to indicate, step by step, how these objectives are to be accomplished. Moreover, this handbook itself helps to further industrial preparedness. As the Foreword indicates, it is designed to be used in conjunction with CD instruction programs for Soviet students of engineering-technological and liberal arts colleges (p. xxiii). In addition to instructing future factory staff members in CD, other measures to increase the operational stability of industrial facilities in wartime include:

1. special emphasis on saving the workers, on whom the operation of such facilities depends;
2. the dispersion (already accomplished) of four-fifths of all newly constructed industrial projects in small and medium-sized towns in accordance with the 8th Five-Year Plan;[6]
3. the reduction of the vulnerability of each vital facility *in situ* (see chapter 6).

THE "WHY" OF SOVIET CIVIL DEFENSE

Anyone even scanning this substantial English translation, *Civil Defense* (1970), or its predecessor, *Civil Defense* (1969), may well ask: What are the reasons for the Soviets' serious concern over civil defense?

Vivid memories of World War II provide one reason. The enormous losses suffered by the USSR in World War II continue to be cited today. According to Soviet estimates, these losses include 20 million people (including "innocent citizens who were murdered and tortured by the Nazis on occupied Soviet territory, ... workers of the Soviet rear who perished as a result of the blockade of cities and aerial bombardment, [and] hundreds and thousands of people ... exterminated in German concentration camps"), 1710 towns and urban-type settlements, more than 70,000 villages and hamlets, 32,000 industrial enterprises, 93,000 collective farms, and 1,876 state farms – a loss of 30% of the national wealth of the land.[7] There are many retired officers and soldiers dubbed "heroes of the Soviet Union" who experienced the horrors of World War II firsthand and who are closely associated with the current Soviet civil defense program.

But it is not only a backward look that contributes to the importance of Soviet civil defense today; it is the Soviet view of a future war as well. Soviets cite statistics to show that in succeeding wars the civilian population bears ever heavier losses. Thus, in World War I only 5% of the 10 million killed were civilians; in World War II, 48% of the 50 million; and in the Korean War 84% of the lives lost.[8] In a future war the Soviets believe that the enemy would launch a nuclear attack not only on strategic facilities, administrative-political centers, and weapons factories, but also on industrial plants, large cities, and rear areas (p. 3). In such a war, the purpose would be to inflict large-scale losses "not only ... on the armed forces, but also – if necessary – on the civilian population," one of the main goals being to "destroy the morale of the population." Moreover, the "military leaders of the aggressive war blocs would attempt to suppress the activities of the resisting state, destroy the political leadership of the country, undermine its military-economic potential, forestall the production of armaments, and seize the strategic initiative in the war" (p. 1).

Chemical and biological weapons would be used along with nuclear weapons because these kinds of weapons make possible "a clandestine attack on the enemy, thus eliminating the threat of an immediate retaliatory strike." "Regions of high population density [might] be struck first by nuclear missiles," causing "an enormous number of casualties among the civilians" (p. 3).

Although Soviet defensive missile forces are regarded as a "reliable means" of protection, "it is not possible to guarantee that some of the enemy rockets will not penetrate . . . ." Significant reduction in population losses may be achieved under such circumstances only by instituting a comprehensive system of CD measures. It is for this reason that "CD assumes an important place in the national defense capability, constituting one of its major components" (p. 4).

Observers of the most current relations between the U.S. and the Soviet Union – especially if they read only U.S. newspapers – might well ask, "But hasn't the sunny climate of detente dampened the zealousness of the Soviet civil defense effort?" Not if we take seriously the words of Marshal A. Grechko, Defense Minister and Politburo member of the Soviet Union, in his report to the Fifth All-Army Conference of Party Organization Secretaries on March 27, 1973: In spite of "the peace program advanced by the 24th CPSU Congress and the practical activity of the CPSU committee and Soviet government to carry it out, . . . the antipopular class nature of imperialism remains unchanged. It has not and will not renounce its aggressive aims. As before, due to imperialism, acute crises are arising in the world, able at any moment to shake the entire system of world relations. . . . Were the imperialists to unleash another world war, . . . we are firmly convinced that victory in this war would go to us – to the socialist social system."[9]

Soviet civil defense planners want to leave as little as possible to chance. They publish such manuals as this one, devoted to various aspects of civil defense.[10] The purpose of this handbook primarily is to tell how the stability of vital industries may be increased so that they may continue to function in wartime. Additional detailed highlights of the 12 chapters are outlined below.

FOREWORD AND INTRODUCTION

The *Foreword* and *Introduction* provide the context for the civil defense program in general and this handbook in particular: "In view of the arms race and the aggressive policy of the imperialist states, the Communist Party and the Soviet government have worked relentlessly to strengthen the defense capabilities of our country and to improve civil defense" (p. xxiii).

The Soviet Union and its socialist allies are cast as peace-loving and good, rigidly adhering to "Leninist principles of peaceful coexistence with nations of different social structure," introducing "a broad and workable disarmament program," and doing "everything possible to maintain peace" (p. xxv). In contrast, the "aggressive imperialist circles . . . the ruling class of the U.S.A., in particular," is cast as aggressive and bad, "conducting a policy of aggression, maintaining an enormous army itself," forcing "its allies in the aggressive bloc to spend a large portion of their budgets in preparing for a new world war," and "set[ting] up a warlike network of aggression – NATO, CENTO, and SEATO – designed to subject the people of the allied countries to U.S. influence and use them in the interest of aggression, especially against the Soviet Union and other Socialist countries" (p. xxv). The "increase in imperialist aggression and reactionary activity" is attributed to "the deepening crisis of capitalism."

In the light of such "aggression," the Soviet armed forces "will continue to equip themselves at a high scientific and technical level, . . . maintain . . . preparedness accordingly to restrain any aggressor," and devote "considerable attention . . . to improving civil defense, which is of continually increasing importance."

CHAPTER 1. CIVIL DEFENSE IN A NUCLEAR ROCKET WAR

The first chapter, as already mentioned, describes the character of possible future wars. It also presents an overview of the Soviet civil defense program.

The *basic goals of Soviet civil defense* are to protect the population, ensure the stability of the economy in wartime, and conduct rescue and emergency-restoration operations at sites of destruction (p. 4). Since advance preparation is necessary, a federal system of appropriate civil defense measures has been inaugurated.

Protection of the population is to be achieved by:

1. early warning of impending attack;

2. dispersal and evacuation of the population;
3. individual means of protection (gas masks, respirators, and protective clothing);
4. construction of shelters for the elements of the population remaining in the cities and radiation protection for those in the outlying areas;
5. reserve supplies of food, water, and medicine in the outlying areas;
6. chemical and biological weapon monitoring stations, reconnaissance teams, and lab control;
7. CD instruction for the entire population;
8. advance preparation of plans and equipment;
9. sanitary, preventive, and antiepidemic measures;
10. preparation and execution of rescue operations in centers of destruction.

Preparing the national economy (vital industries and services) for stable operation under conditions of attack is achieved by:

1. ensuring the reliability of power, gas, and water supplies and creating reserves of raw materials and fuels, spare parts, etc.;
2. improving production processes and providing automatic shutdown when a facility is made inoperative;
3. constructing and equipping shelters in installations and plants and preparing mines as shelters;
4. providing for relocation of vital workers to the outlying zones within commuting distance to their factories;
5. creating protective structures for administrative units;
6. preparing CD formations to perform rescue-restoration work;
7. preparing a plant for immediate switchover to a "basic operational system" (the reduction of plant activities to a range of operations feasible under threat of attack) (p. 6).

Civil defense is organized throughout the entire USSR on a "territorial-industrial" basis. It is under the jurisdiction of the Council of Ministers (and directly under the Ministry of Defense) and is led by the Chief of Civil Defense of the USSR, who is also a deputy defense minister.

The responsibility of organizing and executing CD measures falls to the ministries of the 15 republics, the executive committees of the Councils of Workers' Deputies (equivalent to our county and city governments), and the directors of plants, schools, and other establishments and institutions. Party organs and party organizations exercise control, once the CD measures have been enacted by the ministers, "governors," "mayors," directors, and other appropriate authorities.

The civil defense services which support the civil defense measures of cities are based on the already existing municipal service departments. For example, the transport service is based on the Transport Administration Division, the service for maintaining public order on the militia, the power service on the Department of Power Supply, the fire-fighting service on the municipal fire department, the medical service on the municipal health department, etc. (pp. 8–9). In each case the chief of the service (e.g., the fire chief, head of the medical service, etc.) is in charge of the civil defense functions of his service.

In a national economic facility (factory, establishment) "CD is structured on the 'production principle.' In other words, CD units are set up to function during wartime on the basis of workshop, manufacturing unit, work shift, and work team, and in accordance with the special features of the industry" (p. 13). These plant shifts — work units, work teams, etc., which carry on the essential activities of the plant — make up the civil defense rescue squads, reconnaissance teams, and fire-fighting units.

CHAPTER 2. CHARACTERISTICS OF WEAPONS OF MASS DESTRUCTION

The second chapter describes the characteristics of nuclear weapons and the effects of the explosion of these weapons in the immediate vicinity and at various distances, with regard to the size of the weapon and the conditions under which it was detonated (in the air, at ground level, underground, or underwater). The shock wave, thermal radiation, initial nuclear radiation, and fallout are all described in considerable detail, as well as their effects on people, buildings of various materials and types of construction, blast shelters, fallout shelters, utility systems, and electrical communication lines. Secondary damaging effects of a nuclear blast are also discussed (p. 35). They include, for example, the electromagnetic fields, which generate surges in underground lines, high-wire lines, and radio station antennas and cause damage to insulation and electrical and radio equipment.

A *chemical weapon* is defined as "a toxic material (TM) and the means by which it is delivered" (p. 38). The characteristics and effects of such weapons are described, along with the methods of applying them and the danger areas of chemical contamination which result from their use.

A *biological weapon* is defined as "a pathogenic microbe or toxin intended to injure people, animals, plants, and food supplies, as well as the material with which these are applied" (p. 41). The concept "biological weapon" may include the vectors (insects, ticks) of these microbes and toxins, and also agricultural pests and other biological agents. The classification of microbes into bacteria, viruses, rickettsia, and fungi is given, together with the characteristics of and diseases caused by each class. Biological weapons are applied by aerosol and by vector via rockets, airborne bombs, artillery shells, packets thrown from planes, special equipment for spraying or vaporizing, and sabotage.

CHAPTER 3. METHODS OF PROTECTING THE POPULATION BY DISPERSAL AND EVACUATION

Chapter 3 deals with the dispersal and evacuation of people from cities and their reception and relocation outside the blast areas around cities and other likely targets. It is a detailed chapter, explaining the rationale for removing the urban population from the cities, the precedent for evacuation set during World War II, the feasibility of dispersal and evacuation today, the present plans for accomplishing them if the government decrees, the personnel responsible for carrying out these plans, the means by which the population is notified of the onset of evacuation and dispersal, and the part played by the Party in the whole process.

The rationale for evacuation and dispersal in a period of escalating crisis is simple: (1) Should nuclear weapons be used, major cities and industrial and administrative centers would be attacked; (2) at least 55% of the Soviet population lives in cities (p. 45); (3) therefore, relocating these people in the country can reduce the potential loss of 90% of an unprotected urban population to only "several percent of the total" (p. 46).

The most important element of the population to protect, according to Lenin, is "the worker," the "primary productive factor of all humanity. . . . If he survives, we can save . . . and restore everything . . . but we shall perish if we are not able to save him" (p. 45). The means by which this most valuable resource, the worker, is to be saved is dispersal. *Dispersal* is defined as "an organized departure from the major cities and the distribution in the outer zone of workers and employees of national industrial enterprises that continue to function within these cities in wartime" (p. 46). Also subject to dispersal are "people who . . . operate the city" (e.g., utility workers). "These people must all work within the city but return to the outer zone to rest."

The "outer zone" itself is defined as "the territory between the external border of the area of possible destruction of the city and the border of the region comparable to a state. The boundaries of the zone of possible destruction must be established in relation to the importance of the city and the size of the population." Below is our diagram of the "outer zone," based on Soviet figures in the 1969 handbook, *Civil Defense.*

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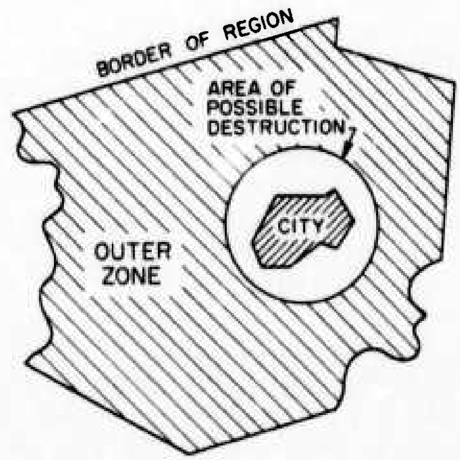

Evacuation refers to the removal from a large city of that portion of the population which does not work in vital industries, and also of those urban enterprises – educational and scientific institutions, etc. – which could be transferred along with their staffs to agricultural areas (p. 46).

The dispersed population would have to be located near enough to the city to commute there and back within 4 to 5 hr, and those workers commuting by train "no further than 5 km from a railroad station." The dispersed workers continue production, working in two 12-hr shifts. While the on-shift group is at work in the city, the off-shift group contains, on standby, the rescue crews, fire fighters, and reconnaissance teams that will march in formations to their own facility if this facility should be attacked.

The responsibility for preparing for dispersal and evacuation falls to the CD staff of each city or region or facility and to special evacuation commissions organized in city and regional executive committees of the Councils of Workers' Deputies (comparable to local and county governments), as well as at industrial enterprises, educational institutions, and housing offices. Evacuation commissions are subject to the control of the civil defense chiefs and work in close cooperation with the civil defense staffs. The composition of the evacuation commissions and of the staffs of the evacuation-collection points, where the people convene for departure by train, motor vehicles, boat, etc., is described in detail, as is the composition of the various committees that receive and distribute the people at the rural end.

The intricate details of the plans for evacuation and dispersal, including such aspects as billeting the urban population among the rural hosts, supplying the transportation for getting them there, assembling them in small groups to be brought to transport terminals, and processing them along the way, are all spelled out in myriad detail. Also designated are plans for meeting the material needs of the evacuees and dispersed persons — food, water, and other essential items, medical services, and even the assignment of jobs to evacuees. The order for dispersal and evacuation is given by the government — first to the various CD staffs, then to the managements of enterprises, offices, and other organizations, and finally to the general population (p. 53).

Closely connected with all aspects of dispersal and evacuation is the political work of the Party. The purpose of "Party-political work" is to disseminate knowledge of CD among the population by "visual aids, . . . oral addresses, the press, radio, TV, and movies, . . . to prepare the people psychologically and strengthen their morale for the . . . grim experiences [of] . . . war," and to maintain morale during the dispersal-evacuation process itself (p. 54). Party-political workers are therefore expected to be very much on the scene not only during peacetime, but also "in the period of threat of enemy attack," during which time they are in the thick of things at the evacuation-collection points, in transit to the rural areas, and in the resettlement zones.

CHAPTER 4. INDIVIDUAL MEANS OF PROTECTION

This chapter describes the devices available for protecting the respiratory system and the skin against toxic, radioactive, and biologically harmful materials. The most important device is the gas mask, of which there are two categories: (1) the filter-type mask, which purifies the air before respiration by removing most of the foreign materials harmful to man, and (2) the air-supplied mask, which makes possible "completely self-contained respiration . . . by providing oxygen in the apparatus itself and by purifying exhaled air to remove gaseous carbon dioxide and moisture" (p. 56).

The filter-type mask, intended for general use, is available in five models and comes in five sizes. In addition, since the 1969 handbook, a baby's protective chamber has been designed for infants up to 1.5 years old and is described in this 1970 handbook (p. 60). Detailed instructions are given on how to select, fit, and check the gas mask and also on how to use and care for it.

The air-supplied gas mask is also described, as are dust-protective respirators used to protect the respiratory organs from harmful aerosols (pp. 64–69).

Special clothing for protecting the skin is made to cover the entire body and is available in "protective ensembles" that include, for example, coverall (or jacket and trousers), rubber gloves, boots, and head covering (pp. 69–71). Rules are given for what to wear under such clothing under various temperature conditions. In addition to the manufactured clothing, improvised skin protection devices are described (pp. 72–73).

CHAPTER 5. PROTECTIVE CIVIL DEFENSE CONSTRUCTION

This chapter is devoted to civil defense shelters — the types, designs, interior arrangements, and equipment, including air supply system, water supply and sewer systems, electrical power, and heating supply, and also means to protect the air intake and exhaust openings from weapons damage. Instructions are given on how to adapt a basement as a shelter, construct a simplified filter system, and build detached fallout shelters of various types of construction and materials. Designs for simple expedient shelters that the population itself can construct under threat of enemy attack are provided, as well as methods of adapting mines as shelters. Finally, rules for shelter use and directions for shelter maintenance are given.

Shelters are first divided into four general categories: (1) blast shelters with industrially manufactured filtering equipment, (2) blast shelters with rugged, expedient filter equipment, (3) fallout shelters prepared in peacetime (both specially built structures and modified buildings), and (4) expedient shelters constructed of available materials during a crisis. Shelters are also classified in accordance with their protective properties, capacity, location, and filtering equipment. Attention is given to the construction of dual-use shelters which can serve specific peacetime as well as wartime purposes.

The filter ventilation unit of a shelter is described in depth with diagrams, for example, of the dust filter, the adsorption filter, and the antiexplosion mechanism to protect the air supply and filter equipment from blast damage. Even such details as the handle of the "butterfly valve" and the electric blower duct are indicated in the drawings (p. 80).

Building instructions with diagrams are given for a number of types of fallout shelters, including, for example, a shelter of unnotched construction for 40 persons (pp. 88–90), a trench-type shelter (p. 91), a dugout (pp. 91–92), and two fascine shelters (pp. 92–93): one in clay ground covered by cane-reed arched fascines and one in sandy soil made of annular brushwood fascines.* [Fascines are reeds or brush tied into bundles.]

CHAPTER 6. TECHNOLOGICAL CIVIL DEFENSE MEASURES TO INCREASE THE CONTINUOUS OPERATION OF NATIONAL ECONOMIC INSTALLATIONS [FACILITIES]

This chapter, as its title suggests, describes specific measures for increasing the "operational stability" of vital installations so that they could continue to function in wartime. The necessity for taking such measures is explained at the beginning of the chapter: "To wreck the enemy's economy has always been the purpose of war" (p. 100). Therefore, "nuclear strikes . . . on national economic facilities" are to be expected in a major war (p. 100). The decision as to what CD measures a specific facility should take is based on a calculation of the probable degree of damage it would sustain in the light of its own importance or its proximity to a city or other potential target (p. 101).

It is assumed that "cities and industrial sites [in general] will be the target of nuclear attack"; but, since it is not possible to know in advance which cities and industrial sites would be selected, "it is necessary to take CD measures in all cities, all population centers, and every economic center." These measures include such national ones as "gradually . . . developing industry in undeveloped regions and limiting the construction of new plants in highly industrialized regions." Other urban planning measures which take into account civil defense include "reducing the building density of urban regions and creating satellite cities, constructing wide major thoroughfares, creating greenbelts, constructing artificial reservoirs, developing suburban zones, and building a network of highways around the city (p. 102). These measures are all discussed in detail.

Planning new towns and renewing existing ones with an eye toward CD are two important civil defense objectives; increasing the "operational stability" of already existing national economic facilities is a third such objective. If the operational stability of a given facility is to be increased, its present operational stability must be evaluated. A facility's operational stability is distinguished from its "survivability." The survivability of a facility is determined by the capability of its buildings and structures to withstand the destructive forces of a nuclear blast. Its operational stability is its capability not only to withstand these forces but also to "maintain production as planned" (p. 105). Thus, an evaluation of a facility's operational stability takes into account the "possibility of continuing work by workers and employees, as well as the possibility of operating the facility in the event of [a partial] breakdown, through cooperation with other plants and suppliers of raw materials."

The assessment of the overall survivability of a facility includes the facility's capability to withstand the entire range of weapons effects from a nuclear strike. Such an evaluation begins with "determining the location of the facility relative to that of the anticipated strike" and goes on to include the capability of the facility to withstand the shock wave (pp. 105–106), the thermal pulse (pp. 106–108), initial nuclear radiation and radioactive contamination (pp. 108–109), the second-

*The successes of groups of untrained Americans in building Russian-type shelters under simulated crisis conditions[11,12] have demonstrated the practicality of the Soviet designs on two important counts: (1) they can be constructed within the 72-hr period which the Russians allow for evacuation and dispersal and (2) they utilize widely available materials, especially growing trees and plants. However, their specified provisions for natural or forced ventilation would not provide enough cooling air to maintain nonlethal effective temperatures inside many of these Russian shelters if they were fully occupied for a day or more during warm or hot weather.[13,14] Furthermore, the habitability of Russian shelters, as described in successive publications, seems to be decreasing over the years – apparently as a result of increasing pressures on Russian civil defense technologists to provide inexpensive protection against the whole range of dangers from nuclear, biological, and chemical war. For example, a comprehensive Russian handbook[15] recently translated at ORNL emphasizes more strongly than ever the airtight sealing of all shelter openings except the small ventilation ducts. These ducts are sized " . . . on the basis of 10 square centimeters (intake) for each person . . . ," with the exhaust duct proportionally small. These are scarcely larger than the vent holes in an Eskimo's igloo! And unlike numerous earlier Soviet publications available to us, this 1972 handbook specifies the installation of fabric or straw filters in the small intake ducts, even of shelters dependent on natural ventilation. One may conclude that the Moscow civil defense authorities, like their counterparts in several other countries, have not thoroughly tested some of the shelters that they are instructing tens of millions of their fellow citizens to be ready to bet their lives on.

ary damaging effects of the weapons (p. 110), and contamination from chemical and biological weapons which could affect the personnel (p. 110).

Once the survivability of both a facility and its operations is estimated, technical engineering measures to increase the survivability of industrial buildings, structures, equipment, and communications systems can be taken. Such measures are most effective and economical when a new facility is planned and built. For currently productive national economic facilities, technical engineering measures to increase stability are geared to specific conditions. However, some general measures which can be applied to any installation include:

1. safeguarding workers and employees from weapons of mass destruction;
2. increasing the administrative survivability of the civil defense [capabilities] of the facility;
3. increasing the survivability of buildings and structures;
4. protecting costly and unique equipment;
5. increasing the survivability of the electrical power supply and also the gas, steam, and water supply;
6. increasing the survivability of utility networks [systems];
7. preventing fires;
8. placing the individual components of production in underground structures;
9. ensuring protection from radioactive, chemical, and biological contamination;
10. increasing the survivability of the supply of technical materials" (p. 111).

Chapter 6 describes these measures in considerable detail.

CHAPTER 7. CIVIL DEFENSE PLANNING

Every national economic facility must have a "civil defense plan," a written document containing all the basic civil defense measures to protect plant personnel, increase the operational stability of the facility during wartime, and administer the civil defense formations "in all stages of their operations" (p. 121). Chapter 7 describes a prototype civil defense plan and also the procedure for developing, checking, and correcting it – a responsibility of the CD chief of each national economic facility and his staff.

"The feasibility of the plan" is emphasized as "the most important thing." Therefore, "only carefully studied, actual concrete data regarding local conditions are reflected in the plan" (p. 122). The basic requirements of the plan include "a complete yet concise presentation, accurate calculations of the time required to complete CD measures, and the economic expediency of these measures, as well as their realism and compatibility with the overall CD plan of the [city] staff superiors" (p. 122).

The overall plan actually consists of many subsidiary ones, which include plans for:

1. dispersing the workers and employees, together with their families, to the outer zone and resettling them in villages and other rural areas;
2. designating plant shelters for the on-shift workers and employees;
3. converting the facility to a basic (limited) regimen according to defense needs;
4. providing plant personnel with individual means of protection;
5. organizing administration, warning, and communications at the facility;
6. performing urgent emergency-restoration work at the facility;
7. protecting food supplies, forage, and water supplies from radioactive and toxic materials and biological agents.

CHAPTER 8. CONDUCT OF THE POPULATION UNDER THE THREAT OF ENEMY ATTACK AND IN RESPONSE TO CIVIL DEFENSE SIGNALS

As the title suggests, the two major sections that comprise this chapter are devoted to specific measures to be taken by the population in response to (1) threat of attack and (2) the eight civil defense signals.

It is on the decision of the government that the population is warned of impending enemy attack (p. 127). The announcement is made directly over radio networks, television channels, and other facilities. Upon this announcement, all CD systems are put on combat readiness, and the following basic measures are taken:

1. all administrative posts, warning systems, communications, reconnaissance units, observation posts, and laboratory control facilities are put on full combat alert;
2. individual means of protection are issued;
3. blast and fallout shelters are made ready for workers on plant shifts which expect to continue production;

4. the command service is organized, and provision is made for maintaining public order on evacuation routes, on travel routes for advancing civil defense forces, and in populated regions;
5. dispersal is accomplished, and shelter is provided in outer zones for workers and employees of installations which will continue, or temporarily interrupt, their production activities in wartime;
6. persons and institutions subject to evacuation (rather than dispersal) are removed to predesignated rural areas;
7. reconnaissance is organized along with the relocation of formations into the outer zone, and civil defense forces and facilities are set up to carry out rescue and urgent emergency-restoration work;
8. mass cover (fallout shelters) is built for the entire population of small cities and rural areas
9. evacuation is organized from large cities, as well as removal and distribution of material goods into the outer zones;
10. food products, forage, and water are protected everywhere from radioactive, chemical, and biological contamination;
11. farm animals and plants are protected.

The first section of the chapter spells out each of these measures in more detail.

The second section lists (p. 131) and describes the eight CD signals and indicates the rules of conduct for the population upon hearing each one of them under varying conditions. The eight signals are:

Air alert
Close protective shelters
All clear
Threat of radioactive contamination
Radioactive contamination
Chemical attack
Biological contamination
Threat of flooding

On hearing the "air alert" signal, for example, all citizens are categorically advised to take refuge in blast shelters or fallout shelters or to make use of the protective features of the terrain "since it is dangerous to stay at home, especially in a multistory house" (p. 131). However, since "what a person does depends on where he is," specific instructions are given for people at home, on the way to the shelter, at work, on a city bus, in a department store (or movie), etc.

There are detailed instructions of what to do in a variety of situations, including, for example, when a shelter is damaged by blast or by fire or when the degree of radioactive contamination is "dangerous" or "strong" or "moderate." There are also instructions on how to decontaminate water by various methods and to use dosimetric instruments to verify that decontamination of food and water is completed, on how to move through contaminated territory when necessary, on how to remove toxic materials from the skin and treat the decontaminated skin area with a liquid from the antichemical kit, and on how to behave in a quarantined area.

CHAPTER 9. RADIATION DETECTORS, CHEMICAL SURVEY METERS, AND DOSIMETRIC CONTROL INSTRUMENTS

Chapter 9 describes the various instruments used to detect and measure radioactivity and to detect and identify toxic materials. The designation, classification, and operating principles of these instruments are discussed in considerable technical detail. Dosimetric instruments, for example, are classified into two basic groups in accordance with their purpose: (1) radiation survey meters, which include activity detectors and roentgenometers, and (2) instruments for exposure dose monitoring, which include radiometers and dosimeters.

The photographic, chemical, scintillation, and ionization methods of detecting and measuring radioactivity are examined. Not only are radiation survey instruments and dosimetric monitors discussed in detail with the help of schematic diagrams, but also explicit instructions for using the specific instruments are given.

Toxic materials in the air, on the ground, or on an object are detected by chemical survey instruments and gas detectors or by analysis of samples in a chemical laboratory. The use of chemical survey instruments makes it possible to identify toxic materials on the basis of the color changes of indicators reacting to these materials (p. 152). The intensity of the color indicates the approximate concentration of the toxic material. Three models of such instruments are examined in detail: the army chemical surveying instrument, the chemical surveying instrument, and the semiautomatic chemical surveying instrument.

CHAPTER 10. ORGANIZING AND CONDUCTING RECONNAISSANCE AT A NATIONAL ECONOMIC FACILITY IN A CENTER OF MASS DESTRUCTION

Reconnaissance is described in this chapter as "the most important means" of enabling the CD formations to accomplish their missions (p. 158). The mission of reconnaissance itself is essentially data gathering. It is to determine the levels of radioactive chemical, and biological contamination in a given area; the location and condition of obstructed blast shelters and fallout shelters; the degree of damage to buildings, engineering systems, and communication lines; and the location of conflagration zones — in short, to provide all the information needed to determine the extent and priorities of necessary rescue and emergency-repair operations, as well as the means for accomplishing them.

According to the means used to gather data, reconnaissance is classified as air, river (or sea), and ground (p. 159). It is the ground reconnaissance, however, which addresses itself to the majority of the problems and which is performed by the civilian CD reconnaissance formations, the military CD reconnaissance units, and by meteorological and sanitary-epidemiological stations and observation posts.

Reconnaissance operations take place over a broad geographical area, including the dispersal-evacuation routes, the evacuated areas, the settlement areas in the outer zone, the travel routes along which CD formations advance to centers of destruction, and the centers of destruction themselves. Reconnaissance groups, which generally consist of three to five teams of three to four persons in each team, are established at the national economic facilities and are recruited from the CD staffs and the plant personnel. Such groups are equipped with means to conduct reconnaissance (e.g., radiation detectors and chemical survey meters), as well as individual means of protection, communications, and transportation.

Civil defense chiefs, their staffs, and service personnel at national economic facilities are responsible for organizing reconnaissance (p. 160). The immediate superior officer for all reconnaissance measures is the reconnaissance chief, who is also assistant chief of staff to the CD chief (commander). The reconnaissance groups of a facility usually operate on behalf of that facility but occasionally serve a higher-level CD staff (p. 161), for example, the CD staff of a city.

Specialized reconnaissance groups and teams are created within the appropriate specialized formations to obtain precise data in a given field of reconnaissance — for example, radiation, chemical, fire, engineering, medical, biological, and veterinary (p. 163). Each of these specialized fields of reconnaissance is described in detail.

CHAPTER 11. RESCUE AND URGENT EMERGENCY-RESTORATION WORK

Chapter 11 is both comprehensive and detailed, covering all aspects of rescue and emergency-repair operations: (1) the CD formations that perform the rescue and repair work, the equipment they use, and the procedure to ensure their protection by removing them to the outer zone on threat of attack; (2) the services and equipment which support the rescue-repair forces; (3) the role of the CD chief and staff of the facility in organizing and conducting rescue repair work; (4) the rescue and repair operations themselves and the specific methods of conducting all aspects of them; and (5) the role of political Party work in rescue-repair operations.

The first section of the chapter begins with a review of the composition of the CD formations (discussed earlier in the handbook). It goes on to describe the equipment used by these formations, including the vehicles and machinery for removing debris and for hoisting, hauling, and transporting loads (excavators, tractors, bulldozers, cranes, winches, etc.), the metal-cutting equipment, and the water-pumping machinery, and concludes with a description of the dispersal plan, whereby the CD formations are transported to the outer region on threat of attack.

The second section of chapter 11 describes the various services which support the formations in their rescue-repair operations and indicates which group provides each service (e.g., medical support is provided by the facility's medical unit, fire fighting by the fire department, etc.). In addition to medical and fire fighting, these services include antiradiation and antichemical, material and technical, engineering, and transportation.

While the organization of the CD staff at a national economic facility is discussed in chapter 1, the third section of chapter 11 defines the specific duties and responsibilities of the CD chief and his staff with regard to the rescue-repair operation. These include organizing the rescue-repair work, evaluating radiation conditions, supervising the rescue and repair work, and ensuring that task force replacements of formations and subdivisions are carried out smoothly.

The fourth section of chapter 11 gets down to the essential details of the rescue and repair operations themselves: reconnoitering the center of destruction, isolating and extinguishing fires, clearing paths and making passageways through ruins, and rescuing victims from destroyed or obstructed blast shelters and fallout shelters, from under debris, and from burning and partially destroyed buildings. In this regard, specific instructions with diagrams are given for such operations as making an opening in a shelter roof with a manual drill, clearing an obstructed shelter with an excavator, and making an opening in a shelter wall. There are also sections on giving first aid to victims, helping people escape from contaminated or flooded areas, and decontaminating persons, clothing, and equipment.

Emergency-repair operations that are treated fully in chapter 11 include reinforcing or demolishing buildings which interfere with rescue work, repairing damaged power, water supply, gas, and sewer lines, and restoring damaged communications lines.

The necessity of maintaining a high "morale" and "combat readiness" in the face of the "extremely great danger" (p. 193) entailed in doing rescue-repair work is recognized by Soviet CD planners. To promote this "high morale" and a spirit of "self-sacrifice" in "defending the Socialist Motherland," the Communist Party conducts "political Party work" (p. 193). This work, conducted at the local Party level and by the Party committee of each facility, includes, in addition to building and sustaining morale, improving the caliber of CD staff work and of services, educating and training the formation personnel, and helping the commanders and CD chiefs at all levels to improve CD. Whether a threat of enemy attack has been announced or an order given to disperse the workers and service personnel to the outer zone or whether the time has come to advance the formations to a center of destruction, the Party workers are on hand to expedite the proceedings and to bolster the courage of formations and casualties.

CHAPTER 12. TRAINING THE POPULATION IN CIVIL DEFENSE

Chapter 12 restates the basic objectives of CD training at national economic facilities: to instruct the working population in (1) the principles of CD and the practical methods of protection against weapons of mass destruction, (2) the CD structure of their own facility, (3) the conduct of rescue and emergency-repair operations in centers of destruction, (4) methods for continuously improving the protection of the workers, and (5) measures to increase the operational stability of the facility in wartime (p. 196).

According to chapter 12, the population is divided into four categories for training purposes. The first category includes children in the first five grades of school* (p. 196). These students receive 15 hr of annual instruction, which includes field exercises, movies, and filmstrips designed to impart practical skills. Children also receive CD instruction in Pioneer camps [which are summer camps comparable to our Boy Scout and Girl Scout camps].

The secondary category includes workers, other plant personnel, collective farmers,† and unemployed persons (p. 197). In addition to instruction in methods of protection against weapons of mass destruction, people in this category also learn the specifics of conducting rescue-repair operations. The CD chiefs — usually the directors of the national economic facilities, collective farms, institutions, etc. — are responsible for instructing their workers. Training of citizens who are not employed (homemakers, retired persons, invalids) is the responsibility of the local CD units and the municipal, rural, and regional CD supervisors.

*According to Major General F. Klimenko, an experimental program was started in November 1970, whereby the students of the first four grades in selected schools received special CD instruction. Its "goal was to determine the most acceptable forms and methods of instruction, as well as the time required by young school children to assimilate the proposed amount of knowledge and skill." As a result of this experimental program, all Soviet children now start to study CD in the second grade. This training is reinforced in the summer Pioneer camps. However, they do not resume their CD studies in public schools until they reach grade 5 [Klimenko, "The Primary Stage of CD Training," *Narodnoye Obrazovaniye* (September 1971)]. Klimenko's article, which states that CD training in so low a grade as the second is an innovation, is contrary to the statement in this chapter that children receive CD training in the first five grades of school. However, two articles in the Soviet publication, *Military Knowledge*, support Klimenko in their statement that CD in 1968 was taught only in elementary grades 5, 6, and 7 ("Civil Defense Training Program for Students in the Fifth, Sixth, and Seventh Grade," and A. A. Sychev, "Study and Expand Experience . . . ," both in *Voyennyyee Znaniya*, No. 9 [Moscow 1968]).

†In accordance with the new Soviet CD training program — ratified by the USSR Chief of CD in 1972 and inaugurated in 1973 — the working population is divided into four basic groups to permit specialized training in each category: (1) CD leadership personnel, the chiefs of the services, and engineering technical personnel, (2) command personnel of the nonmilitary formations, (3) production and clerical workers and farmers who are members of formations, and (4) persons not in formations. The first two groups receive command training each year at their place of work and once every three years at CD schools. The first group undergoes a total of 35 hr of training annually in accordance with a program which is specially developed at each facility. The second group receives 36 to 44 hr — the 20-hr minimum, which is studied by the entire population, plus 16 to 24 hr of additional training. In addition to being trained themselves, these commanders, service chiefs, and specialists provide specialized instruction to the personnel of their own formations. This training includes special tactical studies and exercises which develop practical skills. [See M. Muradyan, "The Civil Duty of Each Citizen," *Kommunist* (Yerevan, 24 March 1973); S. Kuzovatkin, "To a New Level," *Sovetskiy Patriot* (Moscow, 14 March 1973); and M. Ponomarev, "The Alarm Signal," *Kommunist Tadzhikistana* (Dushanbe, 16 March 1973).]

The third category includes students in the ninth and tenth grades of public schools, in professional and technical schools, and in universities (p. 197). Ninth and tenth graders learn, for example, how to conduct themselves in response to CD signals, administer first aid, treat the sick, protect food and water, and decontaminate clothing, equipment, and people. Male students in the special secondary schools are trained to become junior supervisors of CD units at their schools in accordance with their specialized training, while female students are taught sanitary squad work. Students in professional and technical schools receive specialized CD training on the basis of their major field of study. All such students study defense against weapons of mass destruction and how to use and operate radiation and chemical reconnaissance instruments. Students in a program of two years or more also study measures to increase the operational stability of national economic facilities in wartime and gain skill in reconnaissance and observation post activities. Students of institutes of higher learning (universities, colleges) are trained to be members of CD staffs at the national economic facilities and future formation commanders.

The fourth category into which the population is divided for CD instruction includes the intermediate supervisory personnel of national economic facilities, collective farms, governmental organizations, trade institutions, public utilities, cafeterias, and community services (p. 198). These supervisors are trained to work with the population and CD personnel and to direct the formations in conducting rescue and emergency-repair work.

The second section of chapter 12 describes in detail the various programs for teaching the four categories and the course material used in each. The third section is devoted to the qualifications for teaching CD. These include, among other things, adequate training for the job and loyalty to the Communist Party. The fourth section deals with the organization and planning of CD combat training at the national economic facilities. The purpose of this combat training is to continuously increase the level of combat readiness.

Section 5 describes the training program for CD teachers and the development of teaching materials, and section 6 discusses each of the methods and forms of teaching. These include lectures, class problems, exercises, seminars, conferences, field trips, news reports, discussions, exhibits and demonstrations, tactical exercises, and practical sessions.

Section 7 concludes the chapter with a discussion of the various channels and methods of spreading CD information. Such channels include the Communist Party, trade unions, and Young Communist League branches at national economic facilities. Civil defense knowledge can be extended via CD exhibits, meetings, movies, and interviews with teachers and workers on local radio stations.

QUESTIONS NOT ADDRESSED IN THIS HANDBOOK

There are a number of questions which neither this handbook nor its predecessor that we published[5] has chosen to address. For example:

1. How many blast shelter spaces are available for people in cities?
2. To what extent are food and medical supplies stockpiled and available for civil defense use?
3. How many fallout spaces presently exist in the countryside and how many must be built during a crisis?
4. Under what circumstances would the order for evacuation be given?

A FEW WORDS ON THE TRANSLATION OF THIS TEXT

The Soviet text was first very roughly translated and then corrected and edited into grammatical and idiomatic English. While it is not a word-for-word translation, we have attempted to render an accurate transmission of each idea, neither omitting nor adding. The Russian text has only a very few footnotes. Those that do appear are printed at the bottom of the page with an asterisk beside them. With these few exceptions the footnotes in the text are editorial, explanatory material written by us, the U.S. editors. Brackets [] are used to denote such footnotes, as well as all other editorial insertions that have been made. Parentheses () are used to denote Soviet insertions included in the original. To facilitate reader understanding, where Russian metric units occur, we have in some instances placed the appropriate English unit values beside them in brackets.

ACKNOWLEDGMENTS

Finally, the editors wish to acknowledge their appreciation to all the people who assisted in the preparation of this translation. In particular we wish to express our gratitude to the following specialists at Oak Ridge National Laboratory who helped with some of the more difficult aspects of the translation:

Joseph Lewin, Engineer, Neutron Physics Division, for his translation of chapter 3 and for special advice on both technical and linguistic problems.

Francois Kertesz, Head, Specialized Information Services Department, Information Division, for both technical and linguistic assistance.

S. J. Rimshaw, Chemist, Isotopes Division, for technical and linguistic assistance.

G. A. Cristy, Engineer, Civil Defense Section, Health Physics Division, for his thoughtful review of several of the chapters.

Joanne S. Gailar
Cresson H. Kearny
Conrad V. Chester

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Foreword

In view of the arms race and the aggressive policy of the imperialist states, the Communist Party and the Soviet government have worked relentlessly to strengthen the defense capabilities of our country and to improve civil defense. Civil defense is a system of national defense measures directed toward protecting the population, creating necessary conditions for maintaining operational stability of the national economy in wartime, and, if the enemy uses weapons of mass destruction, performing rescue and urgent emergency-restoration work.

In view of the above, the fundamental responsibilities of the higher educational institutions [see note *] with regard to their "civil defense" courses are [1] to train the students — the future specialists — in the methods of protection against weapons of mass destruction, [2] to create practical civil defense measures to be taken both in peacetime and in wartime at the national economic sites, and [3] to enable the military instructors to fulfill their training obligations [at these institutions of higher learning].

[*An institution of higher education is any institute or technical school or trade school above the high school level, with the exception of the university, which is not included in this category.]

The present manual is written in conjunction with a program for preparing students in institutes of higher learning by means of a course in "civil defense" and is intended for Soviet students of engineering-technological and liberal arts colleges. In addition, it may also be used by students of other institutions of higher learning in a general course on this subject.

The following civil defense instructors participated in the preparation of this handbook: P. T. Yegorov, professor and candidate [see note †] of military sciences [Chaps. 1, 2 (Sects. 1 and 2), 6, 8, and 11] and I. A. Shlyakhov [Chap. 2 (Sects. 3 and 4), 3, 4, 5, 9, and 10] — both instructors at the Moscow Highway Institute — and Dean N. I. Alabin (Chaps. 7 and 12) of the Moscow Technical Institute of Light Industry and Candidate of Military Sciences. G. A. Karpov, Deputy Chief of the Ministry of Secondary Specialized Education of the USSR, was responsible for overall supervision.

[†The "candidate" degree is equivalent to a high-ranking scientific degree, but is not given by a university or college, but by an institute — primarily a research institute or an institute of specialized training. Many people have both a university degree and a candidate degree.]

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Introduction

The Communist Party of the Soviet Union and the Soviet government, rigidly adhering to Leninist principles of peaceful coexistence with nations of a different social structure, have done everything possible to maintain peace. The international policies conducted by the Soviet Union are determined by the socialist character of our country. Since an integral part of the struggle is to strengthen universal peace and international security, the Soviet government has introduced a broad and workable disarmament program. However, in contrast to the approach of the Soviet Union and other socialist countries of solving international problems by peaceful means, the aggressive imperialist circles seek to increase international tensions. The ruling class of the U.S.A., in particular, is conducting a policy of aggression.

The United States of America not only maintains an enormous army itself, but also forces its allies in the aggressive bloc to spend a large portion of their budgets in preparing for a new world war. The capitalist world has set up a warlike network of aggression — NATO, SENTO, and SEATO — designed to subject the people of these allied countries to U.S. influence and use them in the interests of aggression, especially against the Soviet Union and other socialist countries.

As pointed out by the 23rd Congress of the CPSU [Communist Party of the Soviet Union], the past few years have been characterized by an increase in imperialist aggression and reactionary activity. The deepening crisis of capitalism, the accentuation of its contradictions, has strengthened imperialist adventurism and increased its danger for the people, for world affairs, and for social progress. The imperialist aggressors have been escalating their subversive activities against socialist countries and states standing in the way of capitalistic development.

United States imperialists, having assumed the role of world policeman, are the major reactionary force at the present time. The U.S. aggressors are conducting a criminal war against the Vietnamese people and are crudely interfering in the internal affairs of many countries and peoples of Africa, Asia, and Latin America. The alliance between the U.S.A. and the Federal Republic of Germany is extremely dangerous to international relations. The imperialist predators are achieving militarization of the economy on a gigantic scale and are preparing for thermonuclear war via the armaments race.

On the basis of a profound Marxist analysis of contemporary international conditions, the Communist Party of the Soviet Union has concluded that the danger of attack by imperialists on the USSR and other socialist countries is currently increasing, and the countries of the socialist block must play a basic role in defending the peace. "Thus," as stated in the fiscal report of the 23rd Party Congress of the CPSU Central Committee, "the Communist Party of the USSR will make tireless efforts to strengthen the defense capabilities of our nation and to consolidate our military alliances with other socialist countries. Our Party sees its duty as maintaining a high level of awareness on the part of the Soviet people of the intrigues of the enemies of peace and will do everything possible, if they attempt to disturb the peace, to prevent being taken by surprise, to ensure that retribution will inevitably and without delay overtake the enemy."*

To these ends, our glorious armed forces are equipping, and will continue to equip, themselves at a high scientific and technical level and will maintain our preparedness accordingly to restrain any aggressors. Considerable attention will also be devoted to improving civil defense, which is of continually increasing importance.

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*Fiscal Report of the 23rd Convention, L. I. Brezhnev, in *Pravda*, 30 March 1966.

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1. Civil Defense in a Nuclear Rocket War

1.1 THE CHARACTER OF POSSIBLE FUTURE WARS

The events of the past few years have clearly shown that the imperialist camp, particularly the United States of America, is preparing itself for dangerous offensives against humanity — a world war using weapons of mass destruction. While preparing to unleash the new world war, the military theoreticians of the imperialist states developed their own lawless doctrine, which attaches great importance to the element of surprise in conjunction with massive employment of nuclear weapons.

It was stated in official documents of the Pentagon that "from now on, surprise would be the key to victory." For this reason, initiating a war with a nuclear rocket strike has acquired a special significance which could prove to be decisive. At the very beginning of a war, the armed struggle would be led by forces and facilities that are in combat-readiness in peacetime. The enemy's basic operation at the onset of a war could be a general nuclear attack which would inflict high-power nuclear strikes on our strategic facilities, administrative-political centers, weapons factories, and government facilities.

It is assumed that the attack would be carried out with all available means for delivering nuclear weapons to the designated targets. Moreover, the military leaders of the aggressive war blocs would attempt to suppress the activities of the resisting state, destroy the political leadership of the country, undermine its military-economic potential, forestall the production of armaments, and seize the strategic initiative in the war.

Intercontinental missiles and aircraft, strategically deployed, play an important role in the fulfillment of these tasks: to reach designated targets with nuclear weapons. Reliance is placed on intercontinental missiles because their warheads are only slightly vulnerable to means of antiaircraft defense. Since these missiles are capable of reaching their targets with enormous speed and of carrying nuclear warheads with tremendous power, it is nuclear missiles that the United States of America is accumulating in its arsenal. Figure 1 shows the strategic missiles of the United States of America.

According to statements of American military leaders, there are about 1000 "Minutemen" missiles in the U.S. and 41 submarines carrying "Polaris" missiles with 16

ORNL DWG 73 4637

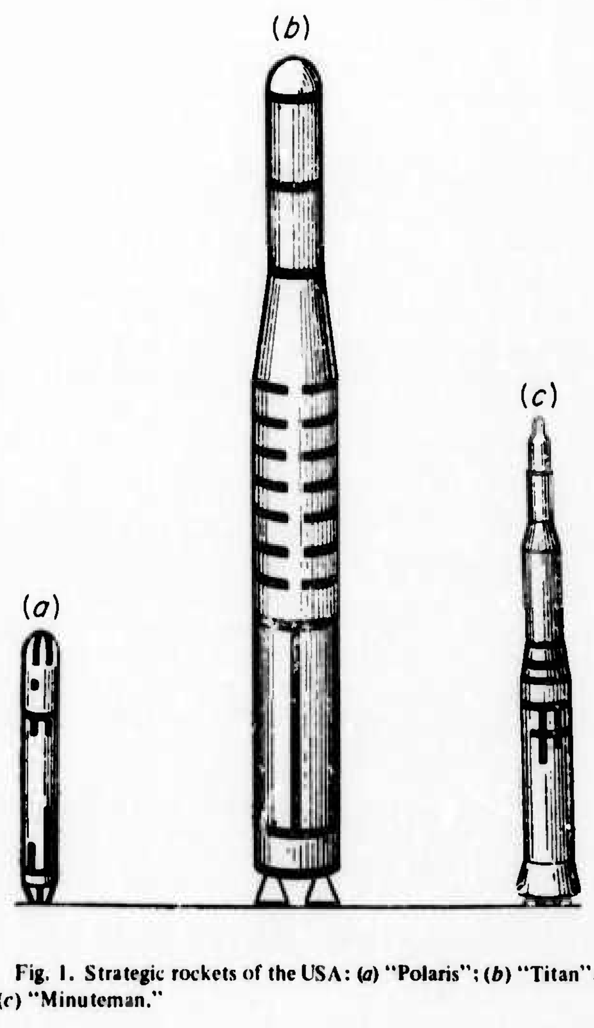

Fig. 1. Strategic rockets of the USA: (*a*) "Polaris"; (*b*) "Titan"; (*c*) "Minuteman."

such missiles on each vessel. Table 1 gives data on strategic missiles in the U.S.

The strategic aircraft includes both heavy- and medium-weight bombers. Heavy U.S. bombers include the B-52 (Fig. 2*a*), medium-weight bombers include the B-58 (Fig. 2*b*).

England is armed with the medium-weight bombers "Vulcan" B-2 (Fig. 2*c*) and "Victor" B-2 (Fig. 2*d*). Table 2 gives data on U.S. and English bombers.

Bombers may carry nuclear bombs and rockets of the "air-to-surface" class with nuclear warheads. The use of airborne missiles enables aircraft to carry out nuclear strikes at great distances without exposing the aircraft to destruction by antiaircraft weaponry. The heavy B-52 bomber is armed with "Hound Dog" air rockets [cruise missiles] (Fig. 3). English medium-weight bombers are armed with "Blue Steel" rockets (see Table 1).

Nuclear weapons are the most powerful of all known means of massive destruction. The payload of nuclear ammunition is ten thousand times greater than that of the largest explosive [nonnuclear] airborne bombs. The effects of nuclear weapons are multiply destructive, causing trauma, burns, and radiation damage.

At the present time, a huge supply of nuclear ammunition has accumulated in the world. According to calculations of foreign specialists, the combined nuclear power in all countries comes to 300,000 to 400,000 megatons, which is equivalent to about 80 tons for each person on earth.

Table 1. Technical tactical data of U.S. strategic missiles

Name of Missile	Engine	Maximum diam (m)	Length (m)	Initial weight (tons) [metric]	Maximum speed (km/hr)	Maximum height (km)	Maximum range (km)	Flight time at full range (min)	Power of warhead (megaton)
				Surface-to-surface					
Titan	ZZhRD	3.0	31.4	136.0	28,000	1300	23,000	50	10
Minuteman-2	ZPRD	1.8	18.0	33.0	26,000	1270	11,100	35	2.0
Polaris A-3	2PRD	1.37	9.52	15.8	20,000	1000	4,600	20	1.0
Poseidon (in planning stage)	2PRD	1.67	10.3	27.0	22,000	1100	5,000	21	2.0
				Air-to-surface					
Hound Dog	TRD	3.7	13.0	4.5	2,500		1,100		1.0
Blue Steel (England)	ZhPD	4.0	10.7	7.0	2,000		320		1.0

Table 2. Technical tactical data of the strategic bombers of the U.S. and England

	Name	Engine	Engine thrust (tons) [metric]	Crew personnel	Flight weight (tons)	Bomb load (tons)	Maximum speed (km/hr)	Maximum altitude in flight (km)	Practical operating range (km)
U.S.	Heavy bomber "Stratofortress" B-52	8TRD	8 × 6.800	6	200	10	1050	17	6400
	Medium bomber "Hustler" B-58	4TRD	4 × 6.800	3	86	4.5	2200	20	3000
England	"Vulcan" B-2	4TRD	4 × 7.700	5	90	4.5	1100	17	3500
	Medium bomber "Victor" B-2	4TRD	4 × 7.700	5	78	4.5	1100	17	3000

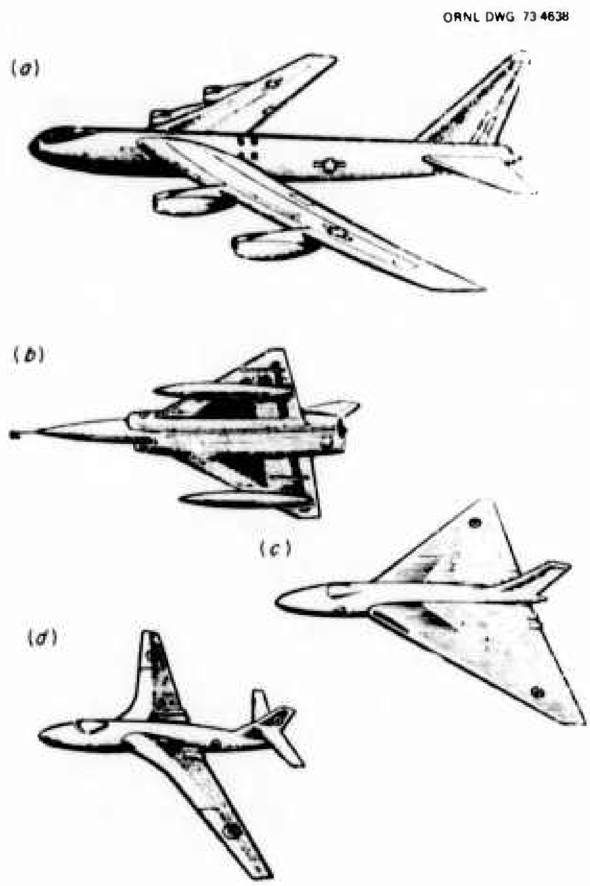

Fig. 2. Strategic bombers of the USA and England.

Fig. 3. "Hound Dog" air rocket [cruise missile].

Considering the availability of nuclear weapons to attack and destroy, one may conclude that a future war unleashed by the imperialists would, unlike past wars, be of a nuclear missile nature. This means that delivery would be by missile, and the primary tool of destruction would be nuclear weapons.

In addition to nuclear weapons, chemical and biological weapons (CBW) might find wide application. The imperialists are preparing to use chemical and biological weapons in conjunction with other means of destruction. It is thought that the military characteristics of these types of weapons make it possible to carry out a clandestine attack on the enemy, thus eliminating the threat of an immediate retaliatory strike.*

The war, if unleashed by the aggressors with weapons of mass destruction, would have its own special characteristics. It would take place over a wide area and would actively involve most of the world's countries and peoples within a short period of time. It would be a war of two opposing systems: socialism and imperialism. It would be an armed encounter with specific goals. A nuclear missile war would be intercontinental, because now it is technically possible to strike at any continent — to transmit military force from one continent to another by means of accumulated strategic weapons.

The targets of destruction are not only weapons centers, but also areas deep within the rear areas of enemy territory, as well as administrative-political centers, industrial plants, and large cities. Destroying the morale of the population is one of the main goals of such a war; thus, in modern warfare there is no real distinction between the front and the rear.

Weapons of mass destruction are used not only to inflict large-scale losses on the armed forces, but also — if considered necessary — on the civilian population. Moreover, the greatest losses may be in densely populated areas, where industrial centers are usually located.

An analysis of the character of future wars leads to the conclusion that regions of high population density may be struck first by nuclear missiles. These strikes may destroy cities, industrial targets, and transportation and may also cause an enormous number of casualties among the population. Thus, the problem of defending the population and the material resources of our country and its industrial-political and strategic centers from the effects of nuclear weapons has become one of the most important concerns of modern warfare.

A reliable means of safeguarding our borders and the main military strength of the Armed Forces is the Strategic Missile Forces, equipped with first-class intercontinental ballistic missiles. Thanks to the relentless efforts of the Party and the government, in a relatively short time the missile forces have been converted into a powerful shield against the cunning intent of the enemy. Immediate destruction of the enemy's means of attack is effected by antimissile and antiaircraft defense. Soviet antiaircraft defense forces, coupled with military air forces, ground forces, and the navy, reliably protect our country from enemy strikes.

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*D. Rothchild, *The Weapons of Tomorrow*, translated from the English, Military Publications, 1966.

However, it is not possible to guarantee that some of the enemy rockets will not penetrate our antimissile defense. Significant reduction in population losses may be achieved in this case only by instituting a comprehensive system of civil defense measures. Thus, civil defense assumes an important place in the national defense capability, constituting one of its major components. Defending the population from weapons of mass destruction is its main task.

Preserving the nation's means of production, ensuring economic stability, and preserving the material and technical resources are matters of paramount importance. Thus, under modern conditions, civil defense has become a factor of strategic importance. To a considerable degree, the success of civil defense measures predetermines the viability and the stability of the country.

1.2 CIVILIAN DEFENSE PROBLEMS

Civil defense (CD) is based on a system of federal defense measures aimed at protecting the population, creating conditions for maintaining a stable economy in time of war, and — if the enemy uses weapons of mass destruction — conducting urgent emergency rebuilding operations.

The basic goals in civil defense are:

1. protecting the population from weapons of mass destruction:
2. preparing the national means of production for economic stability under conditions of enemy attack;
3. conducting urgent rescue, emergency restoration operations at sites of destruction.

Carrying out these tasks requires advance preparation of a system of measures and civil defense planning activities.

1.2.1 Protecting the Population from Weapons of Mass Destruction

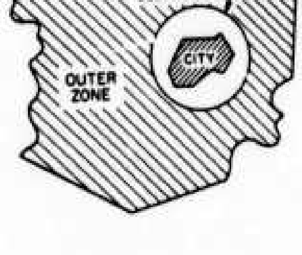
Weapons of mass destruction have various damaging effects, which necessitate a system of defensive measures. Protection against weapons of mass destruction may be achieved with a system of means and methods to be employed under different conditions. No single measure, no one method of defense, will safeguard the people from destruction by nuclear, chemical, and biological weapons.

Protection of the population from weapons of mass destruction can be achieved by:

1. early warning of the population against the danger of enemy attack;
2. decentralization of labor and service enterprises of large cities into outlying areas by evacuation from the cities into rural areas where there are no manufacturing, medical, children's, scientific-research, or educational institutes;
3. individual means of protection for the entire population;
4. construction of shelter and housing for the population remaining in the cities after evacuation; the provision of protection against radiation for the population in the outer zones [see note *]; and the evacuation of the population;
5. defense food supplies, water and the creation of reserve supplies, medical goods, and other essential items in dispersal and evacuation zones;
6. the organization of radiation and CBW monitoring stations, reconnaissance, and laboratory control;
7. necessary general instructions to the population on methods of protection from weapons of mass destruction;
8. preparation and equipment for the development of civil defense;
9. execution of sanitation, preventive, and anti-epidemic measures;
10. preparation and execution of rescue operations in centers of destruction.

Let us examine some basic practical measures for protecting the people from weapons of mass destruction.

[*"Outer zone" or "outlying zone" is used by the Russians in Chapter 3 to mean "the territory between the external border of the area of possible destruction of the city and the border of the region [area, republic]. The boundaries of the zone of possible destruction must be established in relation to the importance of the city and the size of the population."]



To warn the people in time about the danger of impending enemy attack, it is necessary to set up a warning system and maintain a state of constant readiness. The warning is given by civil defense staffs, which use electric sirens set up in the city; industrial and transport whistles; and television and radio channels (loudspeakers) set up on streets, in homes, and in apartments. In addition, electrically powered sirens, local radio units, and radio channels, as well as factory whistles installed in workshops, are used at industrial sites. Various other means of communication, including radio and telephone, are used to warn supervisory personnel.

Protecting the population against weapons of mass destruction is achieved by dispersal and evacuation in conjunction with the use of protective shelters and individual means of protection. Dispersal of workers and employees [see note*] and evacuation of the population from large cities into the outer zones is an effective means of defense, carried out to help the maximum possible number of people escape from a probable enemy strike. To accomplish dispersal and evacuation, it is necessary to carefully plan these measures, prepare designated regions, and organize security in every respect. The assured availability of transport for dispersal and evacuation is of great importance; thus, the use of transportation must be carefully planned and implemented in peacetime.

Protection against radioactive, biological, and chemical contamination is also achieved through the use of individual defense means (gas masks, respirators, and protective clothing). Thus, it is not only very important to safeguard industrial production, but also to teach the entire population in advance to use the simplest possible means of protecting the skin and the lungs.

The construction and utilization of [blast] shelters to protect workers and employees remaining in the city and fallout shelters in places where dispersal and evacuation have taken place guarantee [the availability of] cover [see note †] for the people in case of enemy attack. Existing shelters, cover, and other structures are used for workers and employees who continue their industrial activities, ensuring protection from all injurious factors of a nuclear blast.

[*"Workers" refers to the category of personnel that we would call wage-earners; "employees," to the category of personnel that we would call "salaried."]

[†"Cover" is sometimes used by the Russians to refer generally to protection from both blast effects and fallout; however, it is used much more frequently to mean a fallout shelter. "A shelter," on the other hand, usually denotes a blast shelter.]

For the evacuated population in the outer zones, the greatest danger is from radioactive, chemical, and biological contamination. Thus, fallout shelters, built by the people themselves, are used in dispersal and evacuation areas. Preparation for their construction is carried out beforehand so that the types of shelter and available construction materials are known in advance.

The protection of food supplies and water and the creation of reserve supplies and the basic essentials of life are necessary to ensure survival of the population. Thus, all these measures must be planned and prepared in peacetime. In addition, the people must be aware of the simplest means of protecting food products and water in their homes.

Organizing radiation, chemical, and biological monitoring and laboratory control entails warning the people about the danger of contamination. The Meteorological Service constantly monitors the condition of the air, following the course of radioactive, chemical, and biological contamination. Special observation posts are set up at places of dispersal and evacuation during wartime to warn the people of dangers.

Organizing civil defense and instructing the people, workers, and employees about protective measures against weapons of mass destruction are accomplished by individuals with experience in dealing with complex situations and with knowledge of how to apply defense measures. Community instruction is organized and executed by civil defense chiefs and their staffs, business leaders, institutional and educational establishments, collective farms, state farms, and housing-service offices (government housing offices).

Among the other defense measures, preventive treatment and avoiding or reducing the effects of radioactivity, toxic agents, and biological weapons on the people are very important. Establishing sanitation, preventive, and antiepidemic measures is assigned to the civil defense medical services which make use of medical defense facilities. To carry out medical measures it is necessary to plan in advance the operation of medical institutions, to train medical personnel, to accumulate medical supplies, and to prepare sites for the medical facilities.

1.2.2 Preparing the National Economy [Essential Industries and Services] for Stability of Operations Under Conditions of an Attack

Ensuring the stability of the national economy under conditions of enemy attack is a complex problem, the solution of which depends on the character of the individual installations and services. To solve this problem it is necessary to carefully plan and execute a whole complex of measures.

Stability of operation of national economic establishments during wartime is achieved by:

1. ensuring the reliability of power, gas, and water supplies; creating reserves of raw material and fuel;
2. improving technological production processes, guaranteeing automatic shutdown when a plant, district, or facility is made inoperative;
3. constructing and equipping shelters in installations and plants for employees and workers, primarily according to the number of shifts, and preparing mine shafts and mines as shelters;
4. preparing bases in outer zones for the relocation of scientific-research, construction, and other establishments that are to be evacuated from large cities in order to continue operation in war time;
5. creating protective structures for administrative units;
6. constantly preparing [civil] defense formations [see note *] to carry out rescue and emergency restoration work with consideration of the special features of each plant;
7. performing organizational and engineering-technical work to prepare a plant for changeover to a basic work regimen, providing a series of defense measures for workers and employees, stockpiling material goods and special equipment, preparing to operate with emergency supplies of power and water, providing for fire prevention, and inaugurating other measures in accordance with the nature of production.

The principal measure to ensure the operational stability of establishments and plants in the event of enemy attack is the complete conversion of these sites to the "basic operational system" for civil defense. The "basic operational system" of an establishment or plant refers to the organization of plant operations under threat of attack (as ordered by civil defense signals) to ensure a reduction of losses, should the enemy employ weapons of mass destruction.

[*The civil defense "formation" is the basic unit of Soviet civil defense. A "formation" consists of specially trained and equipped civil defense personnel, prepared to go into centers of destruction after a nuclear strike and conduct reconnaissance operations and perform massive rescue and emergency restoration work. A formation usually refers collectively to a number of highly specialized "groups," "squads," "units," "brigade," or "teams." Most large plants and other large establishments organize and train their own formations.]

Converting these facilities to a "basic operational system" expedites the reduction of plant activities to a range of operations that are feasible while under the threat of attack (proclaimed by civil defense signals). The [emergency] measures are carried out [including] the prevention of fires, explosions, and other problems of a secondary nature (short circuits, destruction of the liquid fuel tanks, etc.). Thus, these plants which must continue certain of their operations, even after the air alert signal has been sounded, are converted to a reduced operating regimen. The workers and employees remaining in the plant take cover individually and make use of other protective measures. In case of radioactive, chemical, and biological contamination, workers and employees take the necessary protective measures. In addition to converting these units to a "basic operating regime," technological measures must be taken to increase the operational stability of an enterprise and ensure the protection of workers and employees.

1.2.3 Performing Rescue and Emergency Restoration Work at Sites of Destruction

Antiaircraft and antimissile defenses notwithstanding, it is still impossible to completely exclude the possibility of nuclear strikes on cities. Therefore, performing rescue operations is one of the vital tasks of civil defense. Thus, civil defense must be ready to immediately go to the rescue of nuclear blast victims.

After the enemy has inflicted nuclear or other strikes, the main task of civil defense is to rescue people in centers of destruction. The rescue work and the emergency restoration operations necessary for its achievement must be executed by trained personnel, specialized brigades, and [military] civil defense troops [see note *]. To carry out rescue operations and emergency rebuilding work at centers of destruction, it is necessary to do the following:

1. organize civil defense units of workers and employees, collective farm workers, and teaching personnel and prepare them to work in centers of destruction;
2. equip civil defense personnel with individual means of protection, other equipment, and various techniques;
3. plan the activities of civil defense personnel well before the threat of enemy attack and the need to

[*It is expected that civilian civil defense formations and military civil defense units would work side by side in performing reconnaissance and rescue-repair operations in centers of destruction as soon after nuclear attack as possible.]

perform rescue and emergency reclamation work at the centers of destruction;

4. verify and specify civil defense plans for instruction of units under conditions simulating those of wartime;
5. create civil defense formations in a short period of time: establish them in large cities and in other zones; distribute them in previously designated zones and prepare them to carry out rescue operations;
6. organize the line of command and clearly establish the authority of civil defense personnel when performing rescue operations.

The success of rescue personnel working in centers of destruction depends on the preparedness of civil defense units to organize rapidly and execute rescue and urgent restoration work.

Thus, by preparing the defense of the cities, population points, and units of the national economy in advance, executing defense measures, and instructing the entire population on how to protect themselves against weapons of mass destruction, it is possible not only to reduce the number of casualties but also to preserve material and cultural values and to guarantee the uninterrupted work in rear [areas].

1.3 ORGANIZATIONAL STRUCTURE OF CIVIL DEFENSE

1.3.1 General Principles of Civil Defense Organization

The Communist Party and the Soviet government pursue a policy of peace, while at the same time relentlessly working to strengthen the defense capability of our country and to improve national defense. Since civil defense is an integral part of national defense, it is organized according to the following basic principles:

1. Civil defense is organized in all territories of the USSR on a territorial-industrial basis. Defense measures and preparations for performing rescue operations are conducted everywhere.
2. Civil defense is organized by agencies of Soviet authority and by directors and managers of departments, plants, institutions, educational establishments, collective farms, and state farms. The responsibility for executing civil defense measures and the constant readiness of Civil defense forces and facilities for action falls to the Soviet Ministers of the United Autonomous Republics, ministry administrators, office and organizational managers, executive committees of Soviets [Councils] of workers' Deputies, as well as to plant managers and leaders of establishments and educational institutions.
3. The supervision of civil defense in outer regions is carried out by chairmen of executive committees of Soviets [Councils] of Workers' Deputies, who are [also] civil defense chiefs.
4. Civil defense is based on the material and human resources of the entire Soviet Union.
5. Organization of civil defense is provided for by the well-thought-out coordination of centralized and decentralized governmental forces and civil defense staffs.
6. Civil defense in the USSR is not only a system of nationwide defense measures, but is also a matter of public concern. Every Soviet citizen is required actively to participate in carrying out civil defense measures, fulfilling an obligation to defend the homeland.
7. Party organs and Party organizations exercise control after civil defense measures have been enacted by ministers, offices, national economy officials, establishments, and educational institutions.

1.3.2 Organization of Civil Defense in Cities

In cities and in populated areas, civil defense is organized by civil defense chiefs. The civil defense chief in the city is the chairman of the Municipal Executive Committee of the Council of Workers' Deputies. Supervision of civil defense in the city is carried out by the staff of employees (Fig. 4).

The civil defense staff of the city is the governing organ of civil defense. The [civil defense] chief of staff reports to the civil defense head [the administrative head] in the city and serves as his first deputy. The chief of staff has the right to issue decrees and orders in the name of the city civil defense head. [In other words, the civil defense chief, like the chief of police or the fire chief, is directly responsible to the city's administrative head, comparable, say, to a U.S. mayor.]

Civil defense services. Municipal civil defense services are created to support civil defense measures, to prepare and formulate civil defense, and to direct its work in centers of destruction. The following civil defense services may be created in the city: communications, maintenance of public order, fire fighting, medical, engineering, communal-technical, protection of animals

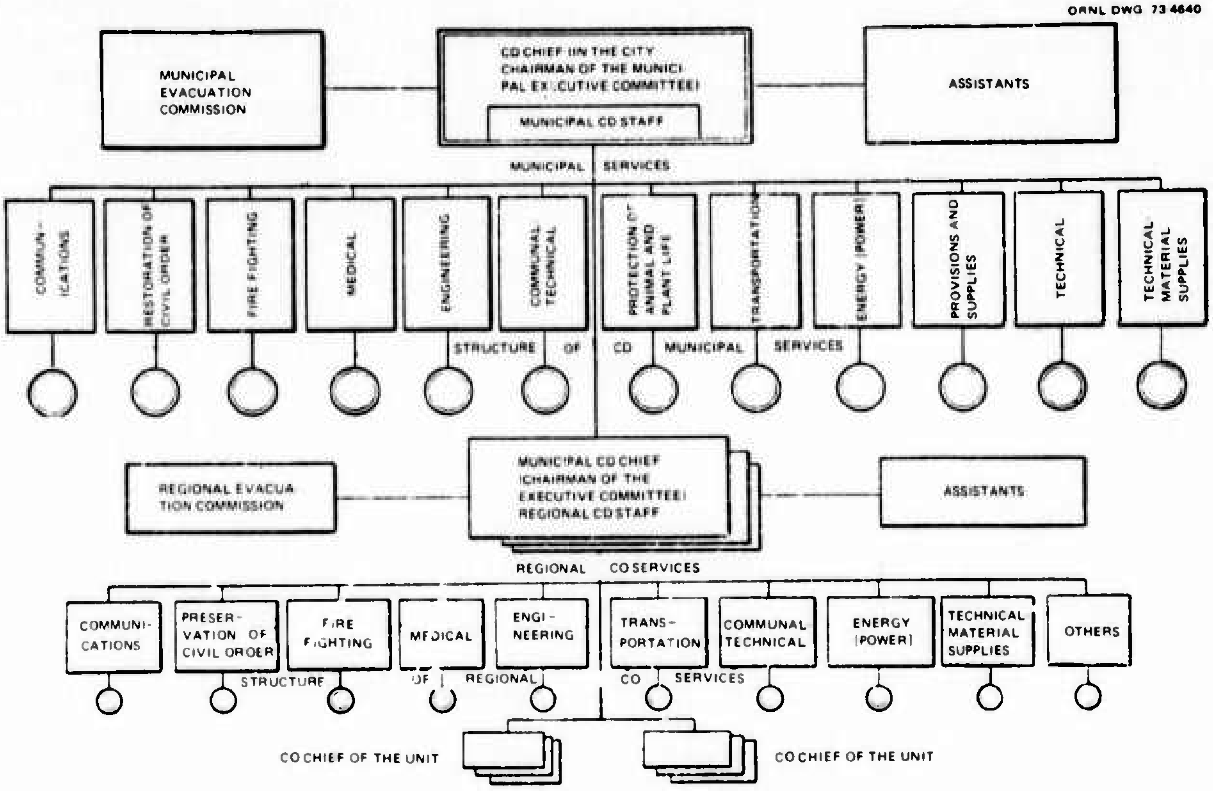


Fig. 4. Diagram of municipal CD organization.

and plants, transportation, energy, provisions and supplies, technical, material-technical supplies, etc.

The communications service is built on the administrative base (division) of municipal communications. The chief of this service is the communications administrator. Efficient communications ensure early warning of the population and municipal officials of the threat of nuclear attack, the danger of radioactive contamination, and the use of chemical and biological weapons by the enemy. This service ensures reliable communications among CD municipal and regional chiefs, sectors of the civilian economy, and officials of the service. It is entrusted with resolving system difficulties and arranging communications between centers of destruction.

The service for maintaining public order is based on the municipal administration division of the militia. The chief of the service is the chief of militia administration. This service is devoted to the maintenance of public order and ensures that all decrees of the Executive Committee of the Council of Workers' Deputies which pertain to civil defense have been carried out by installations and factories, organizations, institutions, and by the people; it regulates traffic on highways and on routes of population evacuation; it controls panic and also guards state property and the personal property of citizens; it isolates centers of destruction (contamination).

The fire-fighting service works through the municipal fire station. It organizes preventive and fire-fighting measures and assures their completion, establishes fire-fighting training, and instructs and supplies fire-fighting personnel. When a fire occurs, this service locates, contains, and extinguishes it, as well as rescues people from burning buildings and structures.

The medical service is based on the municipal health department; the chief of this department is also the chief of the medical service. In peacetime, the medical service operates a whole system of medical evacuation and antiepidemic programs; it organizes training for the service; it conducts special instruction for personnel of the service; it selects and equips the accommodations for the establishment of medical stations in wartime; it provides for the stockpiling of medical sanitation supplies. In wartime the medical service is entrusted with the responsibility of rendering medical aid to the injured [and of assuring] their reception at medical facilities, their decontamination treatment, their evacuation into suburban zones, and their medical treatment.

In addition, the municipal medical service is concerned with the disposition of the sick that are evacuated from medical and preventive-medicine facilities into rural areas; it provides expert advice on water, food products, and food raw materials and administers medical aid to the evacuated population.

The engineering service is based on the municipal housing service. It is concerned with facilities in danger of collapse, as well as with the collapse of poorly constructed buildings and edifices, and the extrication of people from destroyed buildings, blast shelters, and fallout shelters. The service is organized to train and instruct CD personnel. In peacetime, the municipal engineering service is concerned with problems of building shelters and seeing that they are used correctly. When the threat of attack arises, the service supervises construction of blast shelters and fallout shelters for the people.

The organization of the communal-technical service is based on the communal services department of the Council of Workers' Deputies in order to localize and eliminate damage done to utility and communal systems in centers of destruction. In case of radioactive, chemical, or biological contamination, the service is responsible for the decontamination of the territory, installations, equipment, clothing, and footwear and also decontamination procedures for the people. The municipal communal-technical service prepares individual protective facilities and communal facilities (bathing, shower bath, mechanized laundry facilities) for decontamination treatment of the people and for decontaminating clothing and footwear. In addition, the service prepares to use communal techniques, available in the city, for decontaminating the territory (spray washing, scouring, and sand spreading).

The animal and plant life protection service is based on the Agricultural and Veterinary Administration, experimental stations, tree planting trusts, and other establishments.

This service is entrusted with organizing and executing measures to protect animal and plant life, water sources, food supplies, and forage against contamination; it gives veterinary aid to contaminated animals and provides special treatment; it decontaminates stock breeding farms, forage, and water; it checks meat and dairy products and determines the advisability of using the meat of slaughtered animals for food; it slaughters and utilizes injured animals; it declares meat unfit for consumption; it establishes reserves of vaccines and veterinary supplies; it organizes antiepidemic measures and combats destructive insects on agricultural plants.

The transport service is based on the Transport Administration Division and other municipal organizations and facilities concerned with transportation. This service provides for the transportation of evacuated and dispersed workers and employees into the outer areas. If the enemy should use weapons of mass destruction, the service organizes transportation of trained personnel to the centers of destruction, evacuates the injured to medical facilities, and transports food products, essential items, and other material goods necessary for carrying out rescue and urgent emergency reconstruction work. In addition, the transport service checks into the technical condition of the means of transportation and its correct use and maintenance. If the transport system is contaminated with radioactive, chemical, or biological agents, the service organizes decontamination at Transportation Decontamination Stations or Decontamination Areas.

The power service is based on the Department of Power Supply and is designated to prepare in advance for the uninterrupted supply of electrical energy to manufacturing plants and transportation under conditions of enemy attack and to ensure normal operation during a blackout. After elimination of the aftereffects of enemy attack, the power service clears away damaged elements of the electrical supply network and restores service.

The provisions and supplies service is organized in the Administrative Department of Commerce and Food Supplies and is responsible for planning and conducting measures to protect food products, consumable raw materials, and industrial commodities; it secures food products and essential items for the injured and evacuated population; organizes the feeding of personnel and of the population working at centers of destruction; selects samples of food products and essential commodities and conducts tests in the chemical laboratories of the medical service; decontaminates food products and essential supplies; and reprocesses or disposes of contaminated food supplies and industrial goods not suitable for decontamination. The service sets up food and supply stations in rural areas.

The technical service is based on the "agricultural-technical" associations, maintenance agencies (repair shops and vehicle maintenance stations), and establishments and is responsible for the proper maintenance, operation, evacuation, and repair of vehicles, mechanical equipment, and other technical facilities in the civil defense system.

The material-technical supply service is based on the Municipal Planning and Supply Organization and provides CD personnel working in centers of destruction with all types of construction materials, decontamination and washing equipment, reserve equipment and automobile parts, and fuel and lubricants, as well as water for human consumption and technical use. In outlying zones the service equips warehouses and bases and organizes the water supply and the mobile auto-repair units.

In addition to the enumerated services, other services may be organized if the need arises and supportive agencies exist.

The service chiefs are the department directors of offices and organizations which support the service. To guarantee the supervision and administration of service facilities and human resources, staffs composed of a number of workers in those institutions are appointed as service chiefs.

1.3.3 Organization of Civil Defense in Urban Districts

In all urban districts, civil defense is organized by the civil defense head of the district. Civil Defense heads in urban districts are chairmen of the Executive Committees of Councils of Workers' Deputies in these districts. They strive to solve civil defense problems as fully as possible within strictly determined time limits, consistent with national economic planning.

The civil defense head of the urban district sets up a district evacuation commission to organize dispersed workers and employees and to evacuate the people into the outer zones. As a rule, the chairman of the evacuation commission is the Deputy Chairman of the District Executive Committee. The civil defense head of the urban district supervises civil defense through a staff and officials.

The civil defense staffs of the urban district, in addition to regular staff workers, are supplemented by persons working on executive committees of these districts and other organizations; these people serve on civil defense district staffs without being exempt from their usual jobs.

The following civil defense services may be set up in urban districts in the presence of supportive organizations: communications, protection, public order, fire fighting, medical, engineering, communal services, power supply, transportation, material-technical supply, and others, depending on local conditions. The district services organize groups for special purposes and supervise instruction.

1.3.4 Organization of Civil Defense in Rural Areas

Civil defense chiefs of rural regions are chairmen of the Executive Committees of Soviets [Councils] of Workers' Deputies in these regions. They are responsible for the execution of civil defense measures to the fullest extent within a strictly determined time schedule in conjunction with national economic plans. In rural regions, the regional civil defense (CD) chief sets up a commission for the reception and relocation of people evacuated from the cities and urban institutions and organizations. The chairman of this commission is usually the Deputy Chairman of the Executive Committee. Supervision of civil defense in the [rural] region is the responsibility of a CD staff and regional CD employees.

The following civil defense services may be set up in rural areas; communnications, protection, public order, fire fighting, medical, communal-technical, auto transport, protection of animals and plant life, supply of food and other essential items, etc. The responsibilities of these services are similar to those of the municipal services. The special feature of the rural area medical service is that it receives and distributes medical and protective facilities and provides for the sick.

The service for the protection of animal and plant life is based on veterinary facilities and experimental stations. It organizes and trains personnel; takes measures to protect animal and plant life, water sources, and forage against contamination; gives veterinary assistance to injured animals; makes special preparations for and decontaminates livestock farms, forage, and water; checks meat and dairy products and determines the advisability of using slaughtered animals as food; organizes the slaughter and utilization of injured animals; assures a reserve supply of vaccines and veterinary supplies; takes measures against animal sickness; and combats pests on agricultural plants.

1.3.5 Organization of Civil Defense in Units [Establishments] of the National Economy

Civil defense exists at all levels of the national economy to prepare the people in advance for defense against nuclear, chemical, and biological weapons, to assure minimal losses if the enemy should use weapons of mass destruction; to create conditions which increase the operational stability of enterprises and industrial plants in time of war and the prompt performance of rescue and emergency restoration work.

The basic tasks of CD at this level are:

1. developing measures to protect workers, employees, and their families who reside with them in worker settlements near the plant, primarily from chemical and biological weapons;
2. developing measures to increase the operational stability of industrial, power, transport, and communications installations in wartime;
3. ensuring the uninterrupted supervision of services and training and the reliable operation of warning and communications systems;
4. creating, equipping, and preparing civil defense formations and maintaining them in a constant state of combat readiness;
5. generally instructing workers, employees, and their families in defense measures against weapons of mass destruction;
6. ensuring protection of provisions and water supply sources from radioactive, chemical, and biological contamination;
7. carrying out rescue and emergency reclamation work at centers of destruction.

The CD chief of an installation (plant, organization, establishment, and educational institution) is its director, responsible for the organization and the condition of civil defense and for the constant readiness of its forces and facilities to carry out rescue and urgent restoration work. He and his staff are subordinate to the appropriate officials of the ministry (department) in which the installation is located. In large installations the CD chief appoints his own deputies; each one is in charge of one of the following: dispersal of workers and employees, engineering-technical units, and material-technological supplies.

The CD staffs organized at the installations are composed largely of plant workers and staff members who continue to work at their usual jobs at the enterprise. The number of official workers on the staff is determined by the directors of the ministry in which the unit is located (Fig. 5).

The staff of large installations is organized as follows: the chief of staff, assistants in the areas of operational reconnaissance, combat training, and other specialities, at the discretion of the CD chief. Moreover, by decision of the Party, Komsomol [Young Communist League], and trade union committees, the staff may also include

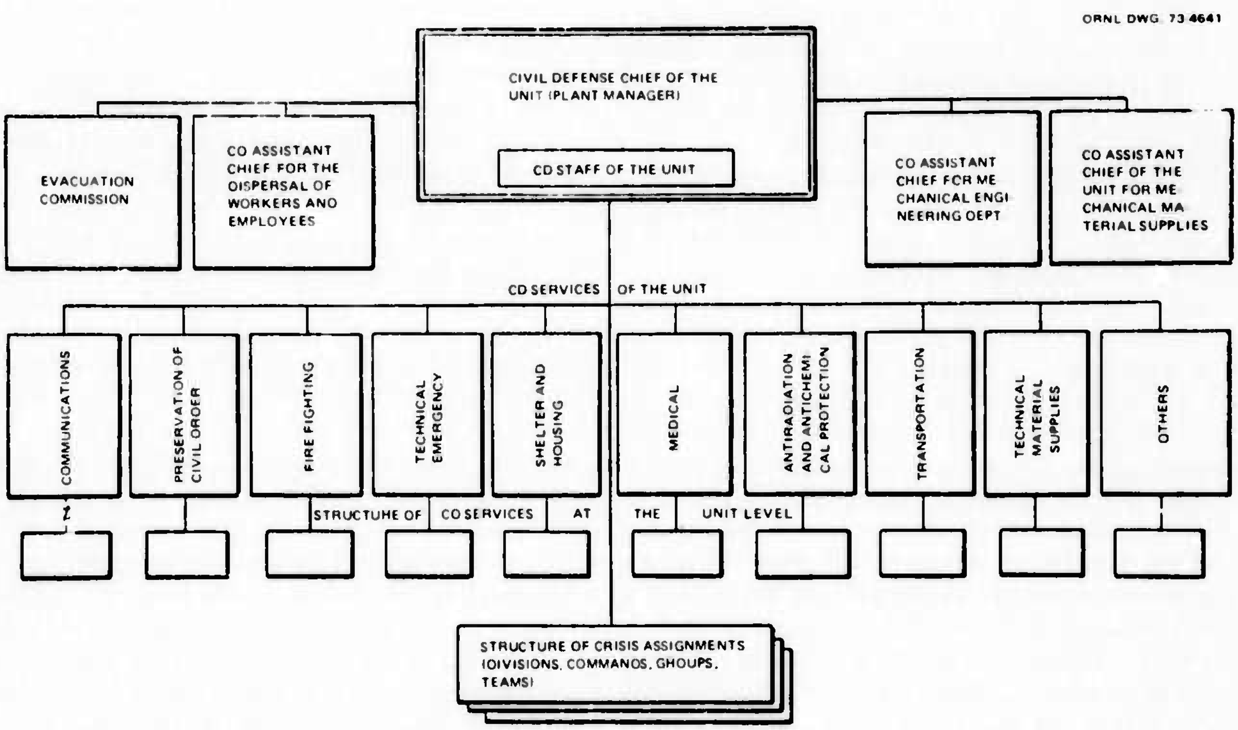


Fig. 5. Diagram of CD organization of a unit.

representatives of the Party, Young Communist League, and trade union as well as of other social agencies.

The CD staff, which operates under the CD chief of the unit, supervises the unit's CD programs. Specifically its functions are:

1. to organize and guarantee uninterrupted administration of civil defense;
2. to ensure early warning of workers, personnel, employees, and the population of worker settlements [the families of the staff and workers] of the threat of attack;
3. to develop CD plans for the unit and to see that they are executed;
4. to develop and carry out measures for the protection of workers, employees, and their families, as well as of industry, from nuclear, chemical, and biological weapons;
5. to organize the combat readiness of CD formations, to instruct workers and employees about protection from weapons of mass destruction, and to control the quality of that instruction;
6. to guarantee the constant readiness of civil defense forces and facilities.

The duties of the civil defense services of an installation. To assure the execution of civil defense measures, as well as the training of civil defense formations and their direction in the conduct of operations at centers of destruction, the following civil defense services are created: communications, protection of public order, fire fighting, emergency-technical, blast and fallout shelters, medical, antiradiation and antichemical protection, transport, material-technical supplies, and others. The number of services is determined by the CD chief of the installation [site]. Depending on the characteristics of the installation and the presence of a supportive organization, other civil defense services may be set up in addition to those enumerated.

The communications service is set up on the basis of the communications unit. The chief of this service is the chief of this communications unit. This service is responsible for assuring an early warning of administrative personnel, workers, employees, and their families to the threat of enemy attack. This service must also organize communications and maintain them in a state of constant readiness. In addition, the communications service must resolve difficulties in the networks and in communication facilities located at the centers of destruction. To ensure a state of constant combat readiness, command and observation posts are provided with all means of warning and communication.

The service for maintaining public order is based on the Section of Departmental Protection. The chief of the service is also the chief in charge of protection of the installation. The service for the protection of public order provides reliable protection of the site and of public order during the threat of enemy attack and during the performance of rescue and emergency restoration operations; it assists in providing prompt cover in accordance with civil defense signals; it supervises the blackout system.

The fire-fighting service is organized as a subsection of the official fire department; the chief of the service is the chief of the fire department. This service designs fire prevention measures and assures their execution; guarantees constant readiness of service forces and facilities; locates and extinguishes fires; assists in antiradiation and antichemical protection by decontaminating affected regions.

The emergency-technical service is based on the production or technical section of the division of the chief mechanic; the chief of the service is the chief of the supportive division which sets up the service. This service plans and executes preventive measures which increase the stability of the basic installations and sets up special engineering and communications systems in the event of enemy attack. It undertakes emergency operations to locate and eliminate trouble in the systems, in communications, and in installations at the site. In addition, this service clears away obstructions and rescues people.

The shelter and housing service is based on the Principal Construction Department, the Communal Housing Department, and the Building Guild, the chief of the service is the chief of the supportive department which created the service. This service is concerned with computing housing expenses for workers, employees, and the other people who work in the settlements; preparing shelter and assuring its proper use; organizing the construction of fallout shelters; guaranteeing the prompt completion of [blast] shelters and fallout shelters in accordance with civil defense instructions. In addition, this service participates in rescue operations when shelters and housing collapse.

The medical service is organized by medical centers, medical and sanitation sections, and outpatient clinics. The chief of the medical service is the chief of the medical center, sanitation section, or outpatient clinic. The medical service assures the constant readiness of medical personnel; plans and conducts hygenic and preventive measures; provides medical assistance to victims and evacuates them to medical facilities; executes sanitation measures in destroyed areas; concerns itself with the medical care of workers and members of their families at dispersal sites.

The antiradiation and antichemical protection service is based on chemical laboratories and plants; the chief of the service is the chief of the laboratory or the chemical plant. This service develops and completes measures for the protection of workers, employees, water supply sources, food units, and supply warehouses from radioactive and toxic substances; organizes and prepares antiradiation and antichemical training and facilities; is in charge of individual means of defense and collective defense facilities and special techniques; organizes posts for radioactive and chemical observation and performs dosimetric checks of personnel; attempts to rectify effects of radioactive and chemical contamination.

The material-technical supply service is organized by the material technical supply department of the area. The chief of the service is the chief of the department. This service plans material and technical supply; at the same time, it supplies personnel with all types of equipment and provisions; it assembles repair technicians and various supplies, arranges their transportation to work stations and maintains records of these activities; it secures provisions and essential items for workers and employees in the area and at dispersal sites.

The transportation service is based on the transportation departments and garages of the unit. The chief of the service is the chief of the department or of the garage. This service plans and implements measures to guarantee that the dispersed workers and employees will be transported to their places of work; organizes the transportation of brigades and equipment to the center of destruction; prepares transportation for the conveyance of workers and employees, and for the evacuation of the injured, as well as for other civil defense objectives; decontaminates transportation vehicles.

The CD service is not organized for small installations [plants, enterprises] of the civilian economy but is entrusted to a department of the installation in question.

Structure of civil defense units. The structure of civil defense consists of divisions, commands, groups, and sections with various assignments, composed of all able-bodied men and women of the country and trained in the execution of defense measures and in rescue and emergency restoration work at centers of mass destruction, as well as in areas of natural disasters and catastrophes. The CD structure is set up in peacetime. It encompasses personnel, transportation, technology, equipment, material, and property. However, men with draft notices, pregnant women, and women with children up to eight years of age are not included in the structure.

The CD structure is organized according to special programs, which are subdivided into crisis assignments and special assignments. The crisis structure involves performance of rescue work, generally in those establishments in which it was set up. The degree of structuring is determined by the CD staff of the unit, with the approval of the CD staff of the region (city), and is then affirmed by the CD chief of the unit. Rescue divisions (commands, groups) pertain to the CD crisis structure.

The structure of special assignments involves specialized tasks in the civil defense system and includes the training organization for civil defense employees.

Establishments, organizations, and communications facilities; public health, transportation, commerce and material-technical supply; veterinary and agrotechnical institutions; and war production activities which will continue to function in war time pretty much as they do in peacetime may be asked to help solve civil defense problems within their existing structure.

Structure of civil defense in industry. In industry, civil defense is structured on the "production principle." In other words, civil defense units are set up to function during wartime on the basis of workshop, manufacturing unit, work shift, and work team, and in accordance with the special features of the industry. The special skills of the workers and the equipment and techniques that are available are also taken into account in the organization of civil defense. Thus, the entire working population of the plant is organized into CD units and subunits within the workshops, shifts, and various areas of production.

These plant shifts — work units, work teams, manufacturing units, etc., which carry on the essential activities of the plant — make up the CD rescue division, commands, and teams, the fundamental units on which CD in industry is based. The rescue divisions (Fig. 6) are responsible for rescuing people from beneath the rubble of destroyed shelters and buildings, removing them from centers of destruction, and giving them first aid. When these tasks have been completed, the rescue workers usually assist engineering and technical workers with their special assignments.

In addition to rescue brigades, the following are organized in industrial concerns:

1. Reconnaissance groups (teams) (Fig. 7), comprised of workers and employees in each production shift, who may be quickly organized to reconnoiter with

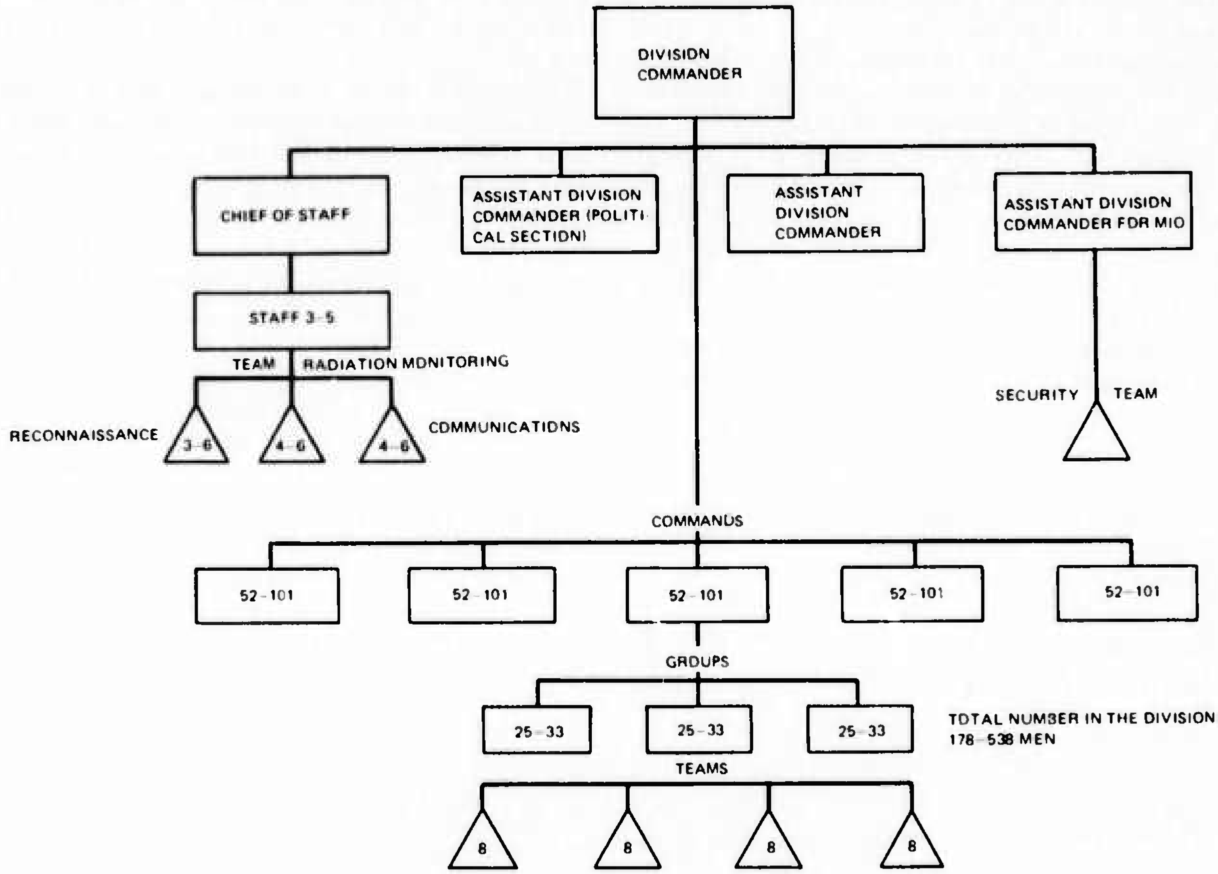


Fig. 6. Organizational chart of the CD rescue division of a unit.

the use of special equipment in dispersal areas, on advance march routes, and in centers of destruction.

2. Observations posts for monitoring radioactivity in air, water, precipitation, and soil in the area of laboratories and other facilities; communications groups (teams) in each shift of the radio unit, communications station, and main power sections; communications groups, including communications teams, equipped with motorcycles, Mopeds, automobiles, and technical means of communication.
3. Decontamination squads (Fig. 8) and decontamination posts in the plant medical stations (dispensaries) and also in shifts at plants where the workers are mainly women (these people are designated to provide first aid at centers of destruction and to evacuate the injured to first-aid stations).
4. Technical emergency teams and groups in the main mechanical, power, and technological departments,

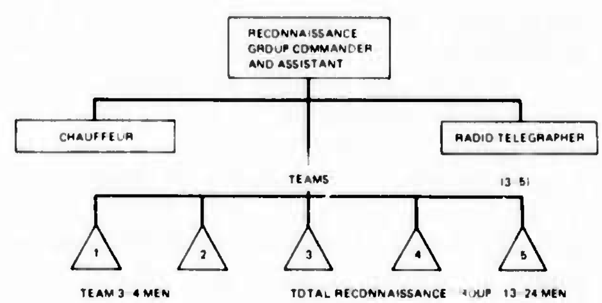


Fig. 7. Diagram of the organization of a reconnaissance group.

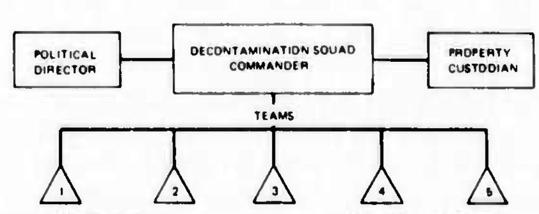


Fig. 8. Organizational diagram of a decontamination squad.

as well as in plant shifts and production sections where workers and employees are involved with engineering systems and communications. Their duties are to construct shelters, prepare and equip underground facilities to shelter the people, clear away rubble, and search for shelters and recover the wounded from them.

5. Fire-fighting commands (detachments) in each shift based on the volunteer fire brigade.
6. Decontamination commands (groups) based on the welfare and the janitorial services of the plant and making use of available communal and decontamination techniques.
7. Stationary laundry and clothing decontamination centers, based on decontamination stations, baths, and showers.
8. Commands (groups) for preservation of public order, based on the departmental militia and the volunteer people's brigade.
9. Groups (teams) for maintaining [blast] shelters and fallout shelters, based on the Main Building, Communal Housing, and Public Works Departments (the number of teams must correspond to the number of existing shelters).
10. Transportation commands, based on the Transportation Work Department and Garages.
11. Mobile food stations and water-carrying units, based on the labor supply departments and plant food and cafeteria departments.
12. Military mine-rescue sections and subsections in the mining industry are utilized for CD training in wartime and are provided with special equipment.

Structure of civil defense in plants and in communications, transportation, and power supply organizations. In addition to the abovementioned services, communications, transportation, and power supply organizations serve as the basis for the following special groups:

1. emergency recovery and technical emergency commands, based on supply line agencies, electrical stations, communications units, radio and telegraph stations, railroad junctions and stations, and sea, river, and air ports;
2. communications commands to ensure communications between the chief administrator, based on the communications office, telegraph office, post office, and training establishments (on the decision of the local Soviet agencies, the personnel of the communications command may include former school teachers);
3. motor-vehicle fleets, based on the motor-vehicle industry.

Structure of civil defense in construction companies. The following CD personnel are appointed in construction and construction-assembly organizations with these special assignments:

1. engineering reconnaissance groups, based on the administration of the construction organization;
2. engineering divisions (units) based on construction, enterprises, building maintenance organizations, and construction-assembly companies;
3. sections (units) for mechanizing work, operating as independent units within the companies, enterprises, and organizations;
4. road and bridge repair and reconstruction sections, operating within road construction and bridge construction combines, enterprises, and companies. These people must repair, restore, and maintain roads and highway facilities which are obstructed and must prepare detours on access routes to permit rescue operations;
5. technical-emergency command, based on combines and administrations for the construction of national oil and gas lines, irrigation canals, water reservoirs, and hydroelectric plants.

Structure of civil defense in institutions and administrative-governmental organizations. If suitable bases are available, governmental institutions and organizations and scientific research and planning organizations organize rescue divisions (commands, groups), reconnaissance groups (teams), communications groups (teams), sanitation squads (posts), fire-fighting commands (detachments), technical emergency groups (teams), commands (groups) for the preservation of public order, and units for servicing [blast] shelters and fallout shelters.

1.3.6 Organization of Civil Defense in Educational Institutions

The CD chief of the educational institution (university, technical school, school) is the rector (director) of the educational institution. In large universities with a large number of teachers and students, civil defense may be organized in the same way as it is for large national industrial plants. A staff and CD employees may be set up in such universities. An evacuation commission is set up to plan for the effective dispersal and evacuation of personnel and is headed by one of the assistant university directors. The CD staff includes official university employees who continue to do their usual work. In universities with a small enrollment the CD chief may appoint an official CD staff from the employees of the institute, in which case they hold dual positions.

All civil defense measures in an educational institution are executed in accordance with the orders of the rector (director) by official workers in the departments of the educational institution.

Structure of civil defense in higher and middle |secondary| educational institutions. The CD structure in educational institutions consists of divisions, commands, groups, and teams. Teachers and university employees are included in the structure. The commander of the structure is appointed by the permanent staff of the educational institution. Colleges and secondary schools recruit personnel and set up crisis training for special civil defense assignments in the educational institution.

Institutions of higher learning must set up rescue divisions (command groups), sanitation squads and sanitation posts composed of students and the regular staff, technical emergency groups (teams), groups (teams) for servicing blast and fallout shelters, which are to be supplemented by administrative personnel; and teams (groups) for the preservation of public order, which are supplemented by student members of the national volunteer services.

During their university years each study group (class) receives a course in civil defense, in accordance with the curriculum and included in the program of the educational institution, as a part of their training on the subject. At the school, each class may have its place in the CD structure in accordance with the overall program of instruction at the university.

Technical schools, secondary schools, and vocational colleges should organize rescue teams (groups), sanitation squads (teams) and sanitation posts, and commands (groups) for the preservation of public order, supplemented by alumni groups, faculty members, and administration personnel.

2. Characteristics of Weapons of Mass Destruction (According to Data of the Foreign Press)

2.1 NUCLEAR WEAPONS

Nuclear weapons are munitions based on the release of internal nuclear energy resulting from an explosive nuclear reaction: fission, or fusion, or [fission and fusion] occurs at the same time. Depending on the means for obtaining nuclear energy, a munition is classified as either nuclear or thermonuclear (hydrogen).

Nuclear weapons include airborne bombs, artillery shells, rocket warheads, naval torpedoes, subsurface bombs, and mines (nuclear land mines). Nuclear weapons are characterized by great power and diverse destructive capabilities, determined by the effects of the shock wave, thermal radiation, penetrating radiation [initial nuclear radiation], and radioactive contamination [fallout radiation].

Nuclear weapons are the most powerful of all known means of destruction. The power of nuclear weaponry is measured by TNT (trinitrotoluene) equivalents. The TNT equivalent is the weight of ordinary explosives (trotyl) with an explosive energy equal to that of the given nuclear weapon. The TNT equivalent is measured in tons, kilotons (1 kiloton = 1000 tons [tons of TNT] or megatons (1 megaton = 1 million tons [tons of TNT]).

According to its power, nuclear munitions are classified provisionally as:

low: up to 15 kilotons;

medium: 15–100 kilotons;

large-scale: 100–500 kilotons;

super: greater than 500 kilotons.

2.1.1 Conditions of Nuclear Explosions

Nuclear bursts may be produced in the air, at ground (water) level, underground, and underwater. Accordingly, a distinction is made between high-altitude, air, ground (water), underground, and underwater bursts.

The center of the burst is the point where the explosion occurs or the center where the fireball is located (Fig. 9). The epicenter [ground zero] of the explosion is the [vertical] projection of the center of the burst to ground level.

A high-altitude burst is a blast which occurs at an altitude of more than 30 km to destroy a rocket, spacecraft, or other projectile.

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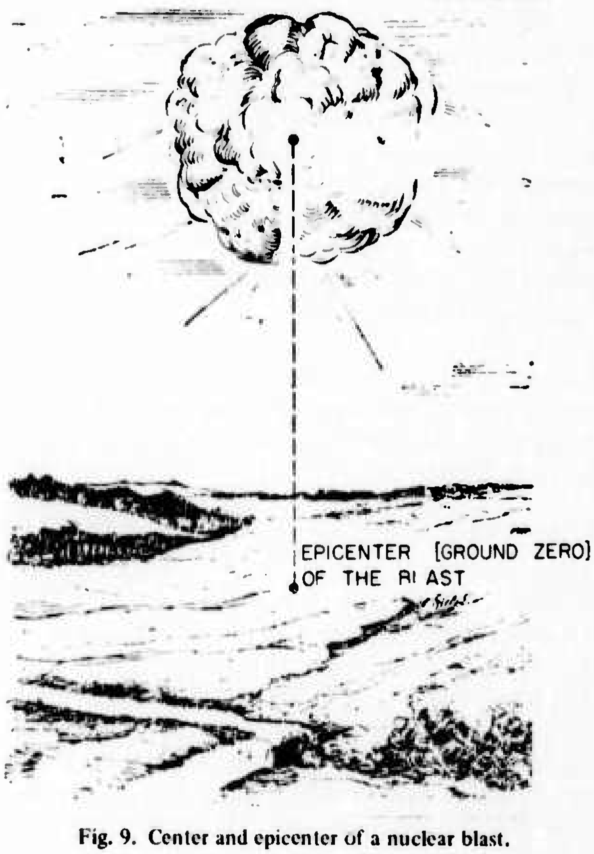

Fig. 9. Center and epicenter of a nuclear blast.

Air bursts are explosions in which the luminous part [fireball] does not touch ground level. Depending on the power of the weapon, the altitude to which the cloud rises can fluctuate between several hundred meters and a few kilometers. An air burst is accompanied by a bright flash, after which the fireball forms, rapidly growing in size and rising upward. After a few seconds the fireball is transformed into a round dark-brown cloud with fire-brightened gaps.

At this time a column of dust extends from the ground to the cloud, rising from the epicenter of the burst. In the case of a high-altitude [air] burst, the pillar of dust rising from the ground does not reach the cloud, which assumes its characteristic toroid form (Fig. 10*a*). The size and the altitude of the radioactive cloud depend on the power of the burst. In the case of a nuclear explosion, it may reach an altitude of 10 to 20 km, but in the case of a thermonuclear explosion, it may reach an altitude of 20 to 40 km. Gradually the radioactive cloud loses its characteristic shape, moves in the direction of the wind, and is dispersed.

An air burst causes destruction by means of a shock wave, thermal radiation, and initial nuclear radiation. Radioactive contamination of an area in the case of an air burst is almost nil since the radioactive products of the blast are lifted with the fireball to very great altitude and are not combined with surface particles.

A surface burst is an explosion on the surface of the earth or at an altitude above it so that the luminous part [fireball] touches the ground and, as a rule, has a hemispherical shape. The fireball increases in size and cools, detaches from the ground, grows dark, and is transformed into a round cloud which, trailing its pillar of dust [stem] behind, assumes its characteristic mushroom shape in a few minutes.

In the case of a surface burst, a crater is formed, the size depending on the power of the explosion and the type of surface. The diameter of the crater, formed of dry sand and clay particles, may be determined according to the formula

$$D = 38\sqrt[3]{q},$$

where D is the diameter of the crater in meters and q is the power of the explosion in kilotons. According to this formula, with explosive power $q = 1$ kiloton, $D = 38$ m; when $q = 1$ megaton, $D = 380$ m. The depth of the crater equals from $\frac{1}{6}$ to $\frac{1}{10}$ D.

At the site of the explosion, the ground melts and is covered with a layer of slag; as a result, a huge amount of vaporized soil is drawn into the cloud, giving it its dark color (Fig. 10*b*).

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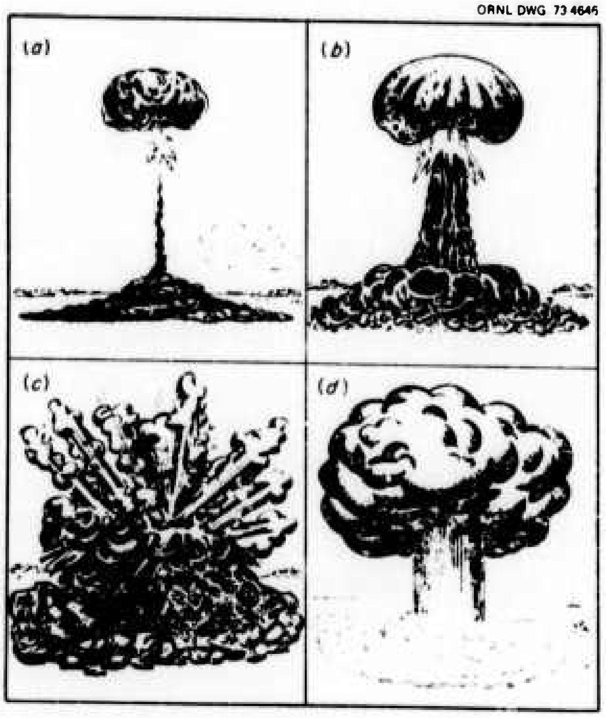

Fig. 10. Types of nuclear bursts: (*a*) air; (*b*) surface; (*c*) underground; (*d*) underwater.

The radius of destruction of the shock wave, thermal radiation, and initial nuclear radiation of a surface burst is less than an air burst. The characteristic feature of a surface burst is a high degree of radioactive contamination in the area of the explosion, as well as in the area over which the radioactive cloud moves.

A surface burst over water is an explosion over the surface of water or at an altitude where the fireball reaches the water surface. A column of water rises under the force of the shock wave, but, on the water surface at the epicenter of the blast, a depression is formed which causes the formation of divergent concentric waves when it is filled in. A large quantity of water vapor is drawn up into the cloud, forming under the effect of thermal radiation. When the cloud cools, the vapor condenses, and drops of water fall in the form of radioactive rain, highly contaminating the water in the area of the explosion and in the direction that the cloud is moving.

The destructive factors in the case of a water surface burst are the shock wave [in the air] and the shock wave which forms on the surface of the water. The effects of thermal radiation and initial nuclear radiation are greatly decreased because of the shielding effect of the large mass of water vapor.

An underground burst is an explosion occurring below the surface of the earth. When there is an underground burst, a large amount of soil is projected to a height of several kilometers and a deep crater, which is larger than the one after a surface burst, is formed at the site of the explosion (Fig. 10*c*).

The basic destructive factor of underground nuclear explosions is the compression wave propagated underground. In contrast to a shock wave [in air], longitudinal and transverse seismic waves are generated in the ground, and the shock wave [in the ground] does not have a clearly defined front. The propagation velocity of the seismic waves in the ground depends on earth conditions and may reach 5 to 10 km/sec. The destruction of underground structures as a result of the effect of the compression wave in the ground is similar to destruction due to earthquakes. Thermal radiation and initial nuclear radiation are absorbed in the ground. An underground explosion causes a high degree of radioactive contamination in the area around the epicenter of the explosion.

An underwater burst is an explosion which occurs under the water at a depth which may fluctuate widely. In the case of an underwater burst, a column composed entirely of water rises to the top of the large cloud (Fig. 10*d*). The diameter of the water pillar reaches a few hundred meters, and the height reaches several kilometers, depending on the power and depth of the explosion. When the water column falls, a strong, concentrically divergent wave forms at its base, which is called the base surge.

The basic destructive factor of an underwater burst is the shock wave in the water, the so-called slick, which has a propagation velocity equal to the speed of sound in water, that is, about 1500 m/sec. In view of the high density and low compressibility of water, the pressure at the front of the shock wave at equal distances is greater than in air. However, when encountering an obstacle, the pressure at the front of the shock wave increases only slightly. The duration of overpressure in the water is also shorter than in the air.

The shock destroys the below-water structures of ships and various hydroelectric structure.

Thermal radiation and initial nuclear radiation in the case of an underwater burst are absorbed by the water mass and by water vapor. An underwater burst causes a high degree of radioactive contamination in the water. When an explosion occurs near the shore, the contaminated water is projected onto the shore by the base wave, which inundates the shore and causes a high degree of contamination to material located there.

2.1.2 Destructive Factors of a Nuclear Explosion

The destructive factors of a nuclear blast are the shock wave, thermal radiation, initial nuclear radiation, and radioactive contamination [fallout].

The energy release of a nuclear blast depends on the type of explosion and the conditions under which it occurs. After an atmospheric explosion, the shock wave generates about 50% of the energy of the explosion, thermal radiation 35%, initial nuclear radiation 5%, and the remaining 10% is present as radioactive contamination [fallout].

Shock wave in air. A shock wave in air constitutes an area of suddenly compressed air propagated in all directions from the center of the explosion at supersonic speeds. The source of the shock wave is a high-pressure zone in the center of the explosion, amounting to billions of atmospheres. The products of the explosion tend to expand, compressing the layer of surrounding air. In turn, this compressed air mass expands and transmits the pressure to adjoining layers. Thus the pressure is rapidly transmitted from layer to layer, forming a shock wave.

The outermost compressed air layer, characterized by a marked increase in pressure, is called the shock wave front. The shock wave front, moving rapidly away from the fireball, resembles a moving wall of highly compressed air. The thickness of the compressed air layer is constantly increasing due to the inclusion of new air masses with the increasing effective radius of the shock wave.

In the immediate vicinity of the explosion center, the speed of the shock wave exceeds the speed of sound several times. The speed of the shock wave gradually decreases, and its pressure is reduced with increasing distance from the center. The velocity and the distance to which the shock wave is propagated depend on the force of the explosion; the more powerful the explosion, the greater the speed and the larger the radius of propagation of the shock wave. Nevertheless, the action radius of the shock wave is affected by the topographic relief of the area, meteorological conditions, and the wind.

Along with rapid propagation of the shock wave front, air particles are compressed into layers in the direction of shock wave expansion. Air moves behind the shock wave front at supersonic speeds and takes on hurricane force.

The direction and the speed of air movement behind the shock wave front are subject to change. When the front reaches any point on the surface of the earth,

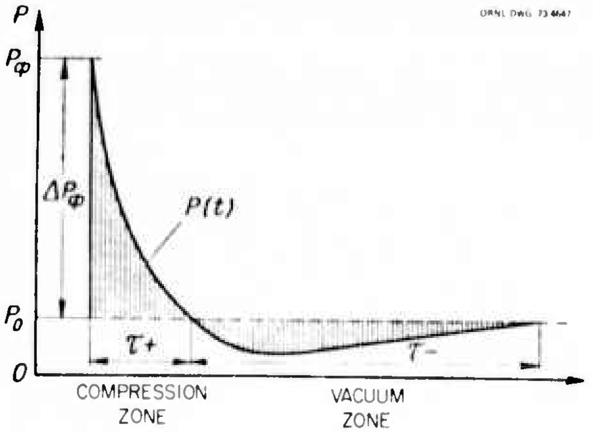

Fig. 11. Pressure changes according to time at any point on the surface of the earth when the shock wave passes through it.

there is an instantaneous increase in overpressure and temperature at that point, and the air begins to move perpendicularly to the shock wave. Subsequently, as the shock wave advances, the pressure behind the front drops below ambient pressure, and the wind direction reverses; the resulting [partial] vacuum follows the zone of compression, that is, the front (Fig. 11). In addition to the change in pressure, there is also a change in temperature. Temperature increases in the compression zone but drops in the vacuum zone. However, the temperature change and the rarefaction of the air are not as important as the overpressure.

The character of the effect of the wave depends on the nature of the explosion. When a shock wave in the air is produced, a spherical shock wave is formed; in the nearest zone, that is, at a distance shorter than the height of the explosion ($R < H$), it descends and is called the incident shock wave (Fig. 12). Upon reaching the surface of the earth, the shock wave is immediately reflected, forming a reflected wave. Due to the slowing down of the air particles and the interaction of the incident and reflected waves, the overpressure is multiplied. This nearest zone is called the zone of regular reflection.

In a zone at a distance greater than the height of the blast ($R > H$), the reflected wave is propagated in the air, which is heated and compressed by the passage of the incident wave. Thus, the velocity of the reflected wave is greater than that of the incident wave. As a result of this, the incident and reflected waves combine, forming the Mach stem wave which has a pressure 4 to 5 times greater than the pressure of the front of the incident wave. The Mach stem wave is propagated along the surface of the earth (see Fig. 12).

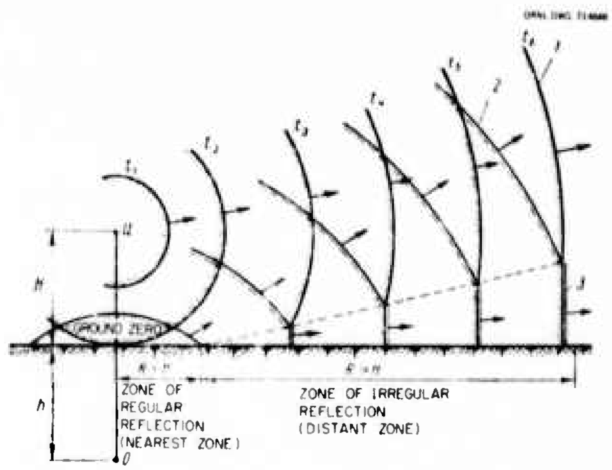

Fig. 12. Propagation of the blast wave; 1-incident wave; 2-reflected wave; 3-Mach stem wave.

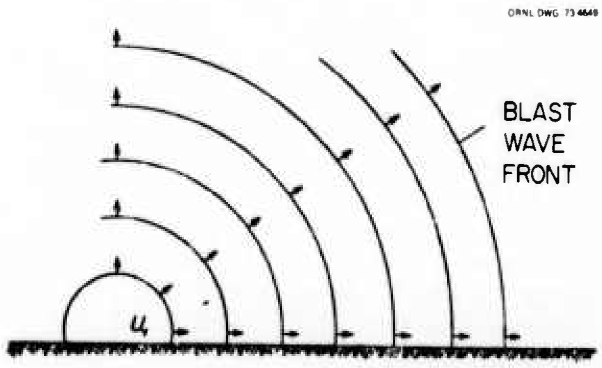

Fig. 13. Propagation of the blast wave in the case of a surface burst.

The zone in which generation and propagation of the Mach stem wave is observed is called the distant zone or the Mach region. Thus, the damaging effect in the immediate vicinity of the shock wave resulting from an air burst is determined by the pressure of the reflected wave, while in the Mach zone it is determined by the pressure of the Mach stem wave.

A surface burst results in a wave with the shape of a continuously enlarging hemisphere, which spreads parallel to the surface of the earth (Fig. 13) and does not have as complex a pattern as does the wave from an air burst.

A boundary can be defined at a determined distance from the center of a surface burst at which the overpressure in the blast wave front will be equal to that of an air burst of equal power. The overpressure will be greater closer to the center of a surface burst than is the case at the same distance of an air burst. Farther from this boundary, in a surface burst the overpressure will be less than in an air burst of the same power.

The radius of destruction of the blast wave from a surface burst is about 20% smaller than the radius of destruction of an air burst of the same power [see footnote *]. The basic parameters determining the destructive effect of a blast wave are overpressure, dynamic air pressure, and duration of action of the overpressure (duration of action of the compression phase).

The destructive effect of a shock wave is determined mainly by the overpressure. The overpressure (ΔP_{Φ}) is the difference between ambient air pressure ahead of the wave front and the peak pressure within the shock wave front. It is measured in kg/cm^2 or in kn/m^2 ($1\ kn/m^2 \approx 0.01\ kg/cm^2$).

The dynamic air pressure (ΔP_{sec}) is the dynamic load created by the air flow. The dynamic pressure is measured in kg/cm^2, as is overpressure. The air pressure depends on the velocity and the density of the air behind the wave front and is closely related to the value of the maximum overpressure of the shock wave. The dynamic air pressure is most significant at overpressures above 0.5 kg/cm^2 [7.35 psi].

The duration of action of overpressure (τ+) (effective duration of the compression phase) is measured in seconds. The more prolonged the action of the blast wave, the greater its destructive effect. The effective duration of the compression phase increases with the increasing power of the explosion.

Effect of the blast wave on people. Immediate injury of people by the blast wave occurs as a result of the effect of the overpressure and the dynamic air pressure. The shock wave envelops a person almost instantaneously and compresses the person from all sides. An instantaneous increase in pressure the moment the shock wave arrives is perceived as a sudden blow. The dynamic air pressure has a projecting effect and can knock a person down, causing injury.

An indirect injury is an injury sustained from fragments of buildings, trees, and other objects which are displaced under the effect of the dynamic air pressure.

The effects of the blast wave are sudden, damaging external organs, causing contusions, that is, injuries of varying degrees of seriousness; these can be classified as:

[* This is equivalent to stating that the area covered by destructive effects of a given intensity caused by a surface burst is 64% of the corresponding area covered by an air burst of the same sized weapon.]

Light, caused by overpressures from 0.2 to 0.4 kg/cm^2 [3–6 psi] and characterized by bruises, sprains, temporarily impaired hearing, and general contusions; *moderate*, occurring at overpressure of 0.4 to 0.6 kg/cm^2 [6–9 psi] and characterized by serious contusions of all organs, damage to the hearing organs, bleeding from the nose and ears, and serious contusions of the extremities; *serious*, occurring at overpressures of 0.6 to 1.0 kg/cm^2 [9–14.7 psi] and characterized by serious contusions of all organs, serious fractures of the extremities, and heavy bleeding from the nose and ears; *very serious*, observed at overpressures higher than 1 kg/cm^2 [14.7 psi]. These injuries may be fatal.

The radius of destruction from the blast wave of a nuclear explosion and the types of injuries depend on the power of the explosion. The radius of destruction to people from building fragments, especially glass fragments, blown out under overpressures of 0.02 to 0.07 kg/cm^2 [0.3–1.0 psi] may increase the radius of immediate destruction from the blast wave.

In our discussion of shielding oneself from the blast wave, we include the direct effect of the blast wave as well as its indirect effect. To protect oneself from a blast wave, it is necessary to have underground structures — shelters which can be depended upon to withstand the effect of the blast wave. Other cover is used in the absence of shelters, such as underground mines, shafts, natural cover, and the relief of the terrain.

The protective nature of the terrain depends on the size and the characteristics of topographic relief relative to the blast. The pressure of the blast wave decreases on slopes facing away from the center of the blast, and thus its destructive effect is reduced. In general, it can be assumed that on the rear of slopes having an angle up to 30° the pressure of the blast wave is decreased up to 5 to 15%, and on an angle of more than 30°, up to 15 to 30%.

The protective features of ditches, washed-out hollows, ravines, and gullies depend on their orientation with relation to the propagation of the shock wave, their depths, and their widths. Ditches, washed-out hollows, ravines, and gullies extending in the direction of shock wave propagation increase its destructive effect. If such relief patterns are situated perpendicular to the direction of shock wave propagation, then they greatly attenuate its destructive effect. For example, at the bottom of a hollow, the pressure may be 2 to 3 times less than in the front of a passing wave. The degree to which the pressure is diminished increases as the hollow becomes deeper and narrower.

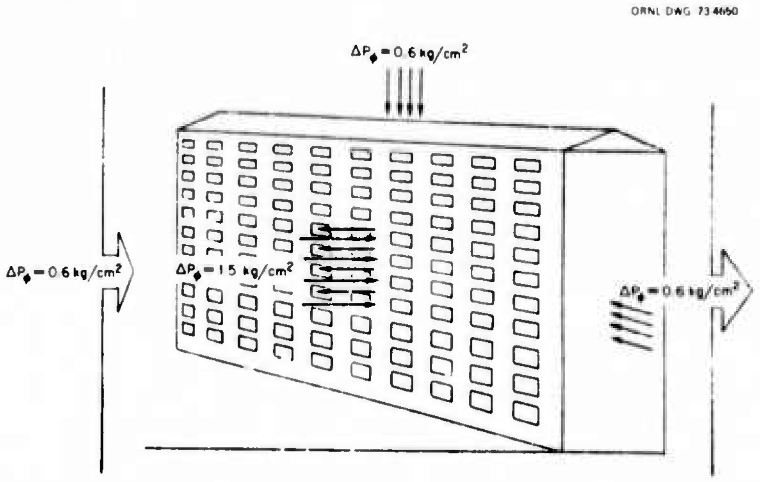

Fig. 14. Effect of a blast wave on a building.

Large topographic forms offer the best shelter — hills, ravines, and canyons of large dimensions. However, small features, such as hills, depressions, and sinkholes, are capable of attenuating the effect of shock waves.

Effect of a blast wave on buildings and structures. This depends on the magnitude of the overpressure and the dynamic pressure of the air moving behind the front of the shock wave. The overpressure of the shock wave and the dynamic air pressure exerted on a structure cause its destruction.

While the wave is freely expanding without encountering resistance, it creates a load, which changes with time, equal to the overpressure of the passing blast wave. When the shock wave encounters an obstacle, it is reflected (forming a reflected pressure Δp_{refl}) and decelerates the mass of moving air, so that the overpressure increases two to eight times. As a result, the obstacle undergoes an impact of tremendous force, which is increased due to the reflected pressure. Reflected pressure can be calculated according to the formula

$$\Delta p_{\text{refl}} = 2\Delta p_{\Phi} + \frac{6\Delta p_{\Phi}^2}{\Delta p_{\Phi} + 7p_0}$$

where

Δp_{refl} = reflected pressure,

Δp_{Φ} = overpressure at the shock wave front,

p_0 = ambient pressure.

For example, if a blast wave encounters a house in its path, the impact occurring on the wall becomes the center of impact. If the overpressure is 0.5 kg/cm² [7 psi], the wall of the house sustains a pressure of 5 t/m^2. If the overpressure increases eight times, the wall will undergo an impact of 40 t/m^2 at the initial moment. Then the blast wave begins to be deflected around the house, exerting pressure on the side walls and on the top, and then on the rear wall. As a result, the house is enveloped with a high pressure and compressed from all sides (Fig. 14); however, the wall facing the blast is subjected to the highest pressure. The effect of the blast wave when bypassing and surrounding the building is a complex interaction of currents, flowing around the building on the top and the sides, creating vortices and high-pressure zones. Figure 15 shows the shock wave deflected around a vertical obstacle when the shock wave is reflected by the surface of the earth behind the obstacle. The shock wave deflected around a building from the sides creates an increased pressure when the two flows meet (Fig. 16). The reflected pressure on the front wall is attenuated in proportion to the extent to which the wave is deflected around the building.

The effect of the overpressure and of the dynamic air pressure when a blast wave destroys a building may vary according to the construction of the building, its size, and its position relative to the direction of travel of the blast wave.

A large building with a large wall area is primarily destroyed by the effect of the initial instantaneous impact, developing as a result of shock wave reflection. This is because the shock wave requires a certain amount of time for deflection, causing a relatively long-term effect of reflected pressure from the shock wave.

Residential buildings with brick walls are less stable and are completely destroyed with an overpressure of

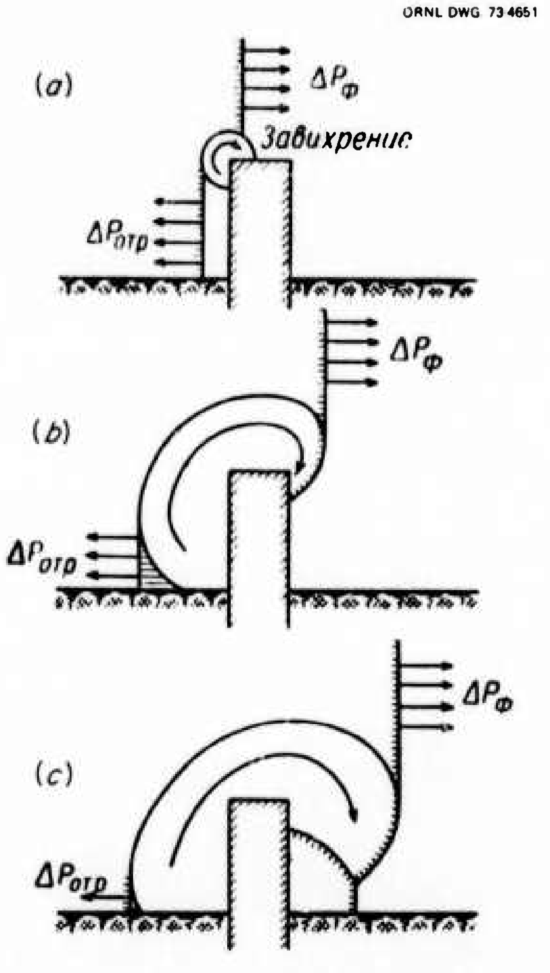

Fig. 15. A blast wave engulfing a vertical obstacle. (*a*) The front reaches the obstacle and exerts full reflected pressure; (*b*) the front passes by the obstacle and partially exerts reflected pressure; (*c*) the effect of reflected pressure ceases, but behind the obstacle the blast wave is reflected from the earth's surface.

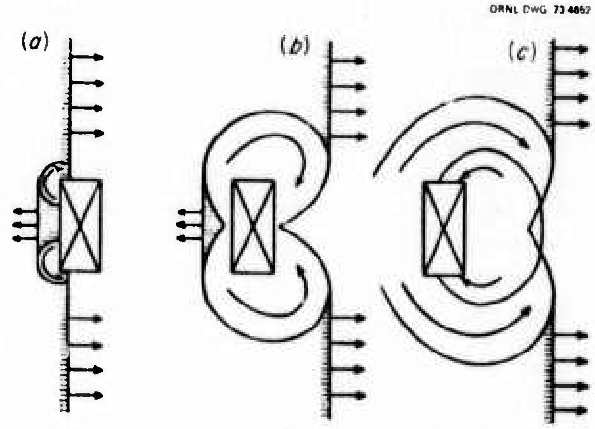

Fig. 16. Blast wave circumventing an obstacle (plan view). (*a*) The blast wave reaches the obstacle, reflected pressure is created, and circumvention begins; (*b*) the front passes by the obstacle and two flows are set in motion in the rear; (*c*) the front moves further and a high-pressure zone is formed behind the obstacle due to the collision of the two flows.

the blast wave equal to 0.3 to 0.4 kg/cm^2 [4–6 psi], but wooden structures are completely destroyed at a pressure of 0.1 to 0.2 kg/cm^2 [2–3 psi].

Among aboveground buildings and structures, the most stable are monolithic iron-steel structures, buildings with a metal framework, and buildings with an antiseismic design, which are completely destroyed when the overpressure of the shock wave equals 0.5 to 0.8 kg/cm^2 [7–12 psi].

The presence of apertures in walls (windows, doors) has an influence on the destruction of buildings and structures since the wave, easily destroying them, penetrates quickly into the building, and the reflected pressure [outside] is compensated by the overpressure within. Complete destruction of the glass in different buildings occurs when the pressure of the blast wave front reaches 0.02 to 0.07 kg/cm^2 [0.3–1.0 psi], while partial destruction occurs at 0.01 to 0.02 kg/cm^2 [0.15–0.29 psi].

A special characteristic of the effect of a wave is its ability to penetrate [blast] shelters, fallout shelters, and other buildings through ventilation openings and vent pipes and its ability to create damage inside, as well as to injure people. When a wave penetrates a building, the temperature quickly rises to a level which may kill people. To avoid this in [blast] shelters and fallout shelters, all openings are sealed, and the air vents are equipped with shock-attenuating devices.

The wave is quickly deflected around high structures of small area (telegraph poles, factory smokestacks, well derricks, and other [such] structures), since they are less likely to generate a reflected wave. For these structures, the destructive effect of the blast wave is determined by the effect of the dynamic air pressure. Such structures, designed to counteract the effect of wind load, are destroyed by the effect of the dynamic air pressure.

Metal oil-well derricks are more stable than industrial buildings. They lose stability and collapse under somewhat higher pressure. The weaker elements of a derrick are the anchor bracings on the supports, the pipe connections, and the shaft braces.

A cracking plant is still more stable than oil derricks; the weakest elements in metal cracking-plant components are the annular reinforced-concrete base supports. Urban reinforced concrete and metal bridges are very stable since they have a small surface and are less susceptible to the dynamic air pressure. The buildings of power-plants are destroyed at the same blast wave pressures as multistory brick buildings.

Home furnaces are put out of commission at a blast wave pressure somewhat greater than the pressure which completely destroys industrial buildings. The first parts of home furnaces to be destroyed are the air-water pipes, the structure itself, and the stoker.

Structures which are sunk deep in the ground are less susceptible to the effects of a blast wave, since the shock wave does not encounter an obstacle during travel and no pressure increase occurs by reflection of the shock wave. Underground municipal utility networks are rather stable against the effect of a blast wave. Housing development buildings are generally destroyed and wells are also damaged. Blast shelters and fallout shelters sunken into the ground can withstand a rather high-pressure blast wave. Depending on the load created by the blast wave, buildings and structures sustain damage of varying degrees.

A. Stone, reinforced-concrete, wood-frame, and frameless residential, administrative, and industrial buildings

1. Complete destruction is characterized by destruction and collapse of one or more of the walls and by a high degree of deformation or collapse of the roof. Fragments fall into rubble within the periphery of the building and around it. Restoration of destroyed buildings is impossible.

2. Heavy damage is characterized by destruction of parts of the walls and ceilings of the lower floors and basements, making future use of the premises impossible or inexpedient.

3. Moderate damage is characterized by destruction of most builtin parts: inside partitions, doors, windows, and ceilings; appearance of cracks in walls and the destruction of attic ceilings and individual sections of upper floors. The basement is preserved and is suitable for temporary use after rubble is removed from the entrances. Rubble does not accumulate around the building, but individual fragments of the structure may be thrown a considerable distance. Restoration is possible in the course of major repairs.

4. Slight damage is characterized by destruction of windows, doors, and thin partitions and the appearance of cracks in walls of the upper stories. The basement and lower floors remain intact and are suitable for temporary use. Restoration is possible in the course of major repair work.

B. Blast shelters and fallout shelters of substantial constructions

1. Complete destruction is characterized by destruction of basic protective structures, entrances, protective doors, and inside equipment. Restoration and future use are completely impossible.

2. Heavy damage is characterized by partial damage to the basic shelter structure, entrances, doors, and protective equipment. Restoration and future use are impossible.

3. Moderate damage is characterized by destruction of entrances and displacement and deformation of basic structural elements. Renewed use of the structure is possible after repair.

4. Slight damage is characterized by partial destruction or collapse of entrances and damage to supporting and safety structures. The building is suitable for use after clearing the entrances.

C. Fallout shelter constructed under threat of attack

1. Complete destruction is characterized by destruction of the roof beams, collapse of the room to the ground, and fallen ceiling parts. Restoration and prolonged use of the building are impossible.

2. Heavy damage is characterized by considerable damage to the roof beams and partial collapse of the walls. Future use is impossible.

3. Moderate damage is characterized by partial damage to roof beams and destruction of entrances, doors, and door frames. Future use of the building is possible after repair.

4. Slight damage is characterized by partial destruction of entrances and parts of the building adjoining them and considerable displacement and deformation of ceilings. The building is suitable for future use.

D. Utility systems, electric communication lines, and interconnections

1. Complete destruction is characterized by broken cables and destruction of pipe lines and high-tension poles over wide areas.

2. Heavy damage is characterized by broken cables and partial damage to pipe lines and high-tension wire poles in localized areas.

3. Moderate damage is characterized by localized broken and deformed cables and pipe lines and deformation and damage to individual high-tension

poles and electro-communication lines and junctions.

4. Light damage is characterized by slight deformation of individual networks and line sections.

The overpressure values causing damage of varying degrees to buildings and structures are listed in Table 3.

The extent of damage in a city depends on the design of the buildings and their number of stories, their density, and [the overall] urban design, because one building may shield others, that is, a building standing near the center of the blast may absorb the impact of the blast wave and reduce its effect on buildings farther away. However, the shielding effect is noticeable only on building densities of 50%. In this case, the overpressure of the blast wave on the buildings may be 20 to 40% less than on a building standing in an unprotected area at the same distance from the center of the blast. If the building density is less than 30%, the screening effect is insignificant and has practically no value.

Table 4 gives the distances [from ground zero] at which [the listed] overpressures in the front of the shock wave may occur.

Thermal radiation. The thermal radiation of a nuclear explosion consists of radiation in the ultraviolet, infrared, and visible regions. In the first fractions of a second after the appearance of the flash, the temperature increases millions of degrees and ultraviolet radiation prevails; as the fireball cools, visible and infrared radiation is emitted.

The source of thermal radiation is the luminous area consisting of incandescent gaseous products of the explosion and air heated to a high temperature. In the first moment that the fireball emerges, its temperature reaches 8,000 to 10,000°C, gradually dropping to 1,000 to 2,000°C. After this time, thermal radiation ceases.

The duration of emission of thermal radiation depends on the yield of the explosion and may continue from a fraction of a second to several seconds. In a blast of a nuclear charge with a yield of 20 kilotons, thermal radiation persists for 3 sec; in a thermonuclear charge of 1 megaton, 10 sec; in a charge of 10 megatons, up to 22 sec. The maximum dimensions of the luminous area and of the duration of thermal radiation increase along with an increase in explosive power.

The basic parameter characterizing thermal radiation is the thermal pulse. The thermal pulse is the quantity

Table 3.

Type of buildings and structures	Overpressure (kg/cm^2) [psi]				
	Complete	Heavy	Moderate	Light	Damage
Building with a steel frame	0.8 [11.4]	0.5 [7.1]	0.3 [4.3]	0.2 [2.8]	0.05 [0.7]
Brick building of a few stories	0.45 [6.4]	0.35 [5.0]	0.25 [3.5]	0.15 [2.1]	0.05 [0.7]
Brick building of many stories	0.4 [5.7]	0.3 [4.3]	0.2 [2.8]	0.1 [1.4]	0.05 [0.7]
Wooden building	0.3 [4.3]	0.22 [3.1]	0.12 [1.7]	0.07 [1.0]	0.04 [0.6]
Underground water and gas lines	15 [213]	12 [170]	7.0 [99]	3.0 [43]	2.0 [28]
Covered manholes	15 [213]	10 [142]	3.0 [43]	2.0 [28]	1.2 [17]
Overhead communication lines	0.7 [9.9]		0.35 [5.0]		
Steel bridges with 30–45 m spans	2.5 [36]	2.0 [28]	1.5 [21]	1.0 [14]	0.5 [7.1]
Reinforced-concrete bridges with 25 m span	2 [28]	1.5 [21]	1.2 [17]	1.0 [14]	0.5 [7.1]
Highways with asphalt and concrete surfaces	40 [568]	30 [426]	10 [142]	3 [43]	1–2 [14–28]
Air fields	40 [568]	30 [426]	15 [213]	4 [57]	1–2 [14–28]

Table 4. [Metric units]

Weapon power, *q* (kilotons)	Overpressure, Δp (kg/cm^2)									
	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
	Distance from ground zero (km)									
20	0.6	0.7	0.8	0.85	0.9	1.0	1.1	1.5	2.0	3.2
	0.7	0.8	0.9	0.95	1.0	1.1	1.2	1.5	1.9	3.0
50	0.8	0.9	1.0	1.1	1.2	1.3	1.4	2.0	2.7	4.5
	1.0	1.1	1.2	1.25	1.3	1.4	1.5	2.0	2.6	4.2
100	1.0	1.2	1.3	1.4	1.6	1.7	2.1	2.6	3.8	6.5
	1.2	1.3	1.4	1.5	1.7	1.9	2.2	2.5	3.2	5.2
200	1.2	1.4	1.5	1.6	1.8	1.9	2.5	2.9	4.4	7.9
	1.5	1.6	1.7	1.8	2.0	2.2	2.6	3.0	3.8	6.4
500	1.7	1.9	2.0	2.3	2.6	3.0	3.4	4.2	6.0	11.5
	2.1	2.3	2.4	2.6	2.8	3.2	3.6	4.4	5.5	9.0
1,000	2.2	2.4	2.7	3.0	3.3	3.6	4.3	5.3	7.5	14.3
	2.9	3.0	3.4	3.5	3.6	4.0	4.5	5.4	7.0	11.2
2,000	2.7	3.0	3.3	3.6	4.2	4.6	5.6	6.8	9.5	18.0
	3.4	3.7	3.9	4.2	4.6	5.2	5.7	7.0	8.8	14.2
3,000	3.2	3.4	3.7	4.2	4.6	5.4	6.3	7.8	11.0	20.5
	4.0	4.2	4.5	4.8	5.2	5.7	6.5	8.0	10.1	16.2
5,000	3.7	4.2	4.4	5.0	5.6	6.5	7.6	9.2	13.0	24.0
	4.7	5.0	5.4	5.7	6.2	6.8	7.8	9.3	12.0	19.5
10,000	4.8	5.3	5.6	6.3	7.0	7.9	9.3	11.4	16.2	31.4
	6.9	6.3	6.7	7.2	7.7	8.5	9.6	11.6	15.3	24.5

[English units]

Weapon power, *q* (kilotons)	Overpressure, Δp (kg/cm^2)									
	14.2	12.8	11.4	9.9	8.5	7.1	6.7	4.3	2.8	1.4
	Distance from ground zero (miles)									
20	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.9	1.2	2.0
	0.4	0.5	0.6	0.6	0.6	0.7	0.7	0.9	1.2	1.8
50	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.2	1.7	2.8
	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.2	1.6	2.6
100	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.6	2.4	4.0
	0.7	0.8	0.9	0.9	1.0	1.2	1.4	1.6	2.0	3.2
200	0.7	0.9	0.9	1.0	1.1	1.2	1.6	1.8	2.7	5.0
	0.9	1.0	1.0	1.1	1.2	1.3	1.6	1.9	2.4	4.0
500	1.1	1.2	1.2	1.4	1.6	1.9	2.1	2.6	3.7	7.1
	1.3	1.4	1.5	1.6	1.7	2.0	2.2	2.7	3.4	5.6
1,000	1.4	1.5	1.7	1.9	2.0	2.2	2.7	3.3	4.7	8.9
	1.8	1.9	2.1	2.2	2.2	2.5	2.8	3.4	4.3	7.0
2,000	1.7	1.9	2.0	2.2	2.6	2.9	3.5	4.2	5.9	11.2
	2.1	2.3	2.4	2.6	2.9	3.2	3.5	4.3	5.5	8.8
3,000	2.0	2.1	2.3	2.6	2.9	3.4	4.0	4.8	6.8	12.7
	2.5	2.6	2.8	3.0	3.2	3.5	4.0	5.0	6.3	10.0
5,000	2.3	2.6	2.7	3.1	3.5	4.0	4.7	5.7	8.1	14.9
	2.9	3.1	3.3	3.5	3.9	4.2	4.8	5.8	7.5	12.1
10,000	3.0	3.3	3.5	3.9	4.3	4.9	5.8	7.1	10.1	19.5
	4.3	3.9	4.2	4.5	4.8	5.3	6.0	7.2	9.5	15.2

NOTE: The first values give the distances [from ground zero] for an air burst; the second values give the distances for a surface burst.

of energy incident on 1 cm^2 of a surface, perpendicular to the direction of propagation, during the whole interval of luminescence. The thermal pulse is measured in calories per square centimeter or in joules per square meter (cal/cm^2 or J/m^2).

The magnitude of the thermal pulse depends on the power and the type of blast, the distance from the center of the blast, and the degree of thermal radiation attenuation in the atmosphere. The thermal pulse decreases in proportion to the square of the distance from the center of the blast.

The energy of thermal radiation incident on the surfaces of an object is partially absorbed by the surface layer of the material and partially reflected from its surface; if the surface is transparent, then part of the energy is transmitted through the object. The absorbed thermal radiation is converted into thermal energy which causes the surface layer of the material to heat. Heating may be so great that carbonization or combustion of the heated material is possible, and softening or melting of noncombustibles may result.

Ignition of materials by thermal radiation depends on the distance, the type of blast, atmospheric conditions, and the nature of the materials. Atmospheric conditions have great influence on the ignition of materials.

In an air burst, the luminous area has the shape of a ball; thermal energy is absorbed less, and the effective radius of thermal radiation has a maximum value.

In a surface burst, the luminous area has the shape of a hemisphere, which rises above the surface of the earth and is transformed into a fireball. In this case, the main portion of the thermal pulse propagates almost parallel to the earth's surface or touches the ground at a very acute angle. Part of the thermal radiation is absorbed by the ground. The thermal pulse close to the blast site reaches enormous magnitudes. At distances from the blast site greater than the altitude to which the fireball ascends, the thermal pulse is less than in an air burst. This is true because in a surface burst a considerable part of the thermal energy is dissipated by melting the earth in the center of the blast.

Effect of thermal radiation on people. The effects of thermal radiation on people are burns on exposed skin and eye injuries. Depending on the magnitude of the thermal pulse, the burns may be classified into three degrees: *First degree burns* occur with thermal pulses of 2 to 4 cal/cm^2 and are characterized by surface damage to the skin, reddening, edema, and nausea; *second degree burns* occur with thermal pulses of 4 to 10 cal/cm^2 and are characterized by the formation of vesicular blisters on the skin; *third degree burns* occur with thermal pulses of 10 to 15 cal/cm^2 and are characterized by necrosis of the skin [localized death of skin cells] and open lesions.

The seriousness of injuries to people from thermal radiation depends not only on the degree of the burns, but on the extent of the surface area of the body that is injured. The effective radius of thermal radiation causing first, second, and third degree burns to people depends on the power of the nuclear explosion.

The degree of burns from thermal radiation on covered parts of the skin depends on the character of the clothing, its color, density, and thickness. People dressed in white, loose-fitting clothes or other lightly tinted clothes are usually burned less by thermal radiation than people dressed in dark-colored, tight-fitting clothes.

Burns can also be caused by fires resulting from thermal radiation. These burns cannot be distinguished from burns caused by thermal radiation.

There are three possible types of damage to the eyes caused by thermal radiation: (1) temporary blinding, which lasts for a few minutes; (2) burns on the fundus of the eye [part of the eye opposite the pupil], occurring at great distances, when looking straight into the blast; (3) burns on the cornea and eyelids, occurring at the same distances as skin burns. When the eyes are closed, temporary blinding and burns on the fundus of the eye are prevented. Various objects which create a shadow may serve as protection from thermal radiation, but the best results are obtained by the use of blast shelters and fallout shelters, which simultaneously provide protection from other damaging effects.

Effect of thermal radiation on buildings and structures. Depending on the nature of the material, thermal radiation causes melting, charring, and ignition which leads to fires and conflagrations in populated areas. At distances close to the center of the blast ($R < H$), the thermal radiation is incident vertically or at angles close to 90°, but at greater distances ($R > H$) it is incident at smaller angles, almost parallel to the earth's surface. In this case, thermal radiation goes through windows into rooms and may set household objects afire: rugs, curtains, upholstery, furniture, books, etc. (Fig. 17).

The effect of thermal radiation or of the blast wave in the city may cause individual or group fires, conflagrations, or fire storms involving many conflagrations.

An individual fire is a fire enveloping one house or a group of buildings. In a nuclear explosion, several individual fires may occur which may be transformed into group fires or conflagrations.

A group fire is a combination of individual fires resulting from a nuclear explosion enveloping more than 25% of the buildings in a given populated area.

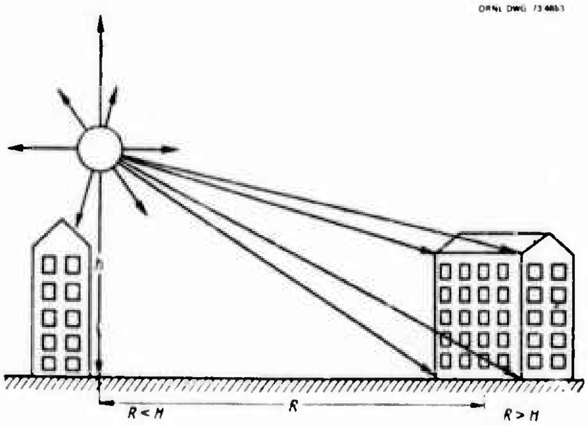

Fig. 17. Direction of thermal radiation for a nuclear blast: At $R<H$ the thermal radiation is directed onto the roof; at $R>H$ the thermal radiation penetrates through the window.

A conflagration is defined as a group fire which envelops more than 90% of the buildings. A fire storm is a special type of conflagration, so-called when the urban area (not less than 250 hectares) is enveloped by a conflagration with a strong (hurricane-like) wind blowing from all sides toward the center of the blast at a speed of 50 to 60 km/hr [31–37 mph] [see note *], because a powerful ascending draft develops in the center of the fire, creating conditions for a hurricane-like wind.

In August of 1945, a fire storm occurred in the city of Hiroshima which raged for 6 hr, as a result of an atomic bomb dropped by the United States. In consequence, a large part of the central city was completely destroyed by fire. About 60,000 homes were destroyed. Hurricane winds blowing toward the center of the blast for 2 to 3 hr reached speeds of 50 to 60 km/hr [see note]. Later, for about 6 hr, the velocity was reduced to that of a moderate wind.

Combatting fire storms is impossible; even high-power fire-fighting equipment cannot cope with the fire. Thus, it is extremely important to take all measures to prevent the development of a fire storm if the enemy uses nuclear weapons. The speed with which fires spread in a city depends on the character of the buildings and on wind speed. If the wind has a speed of 5 to 7 m/sec [11–16 mph], then the fire may spread in a city with brick buildings with a speed of 100 m/hr and more, and, in populated areas with flammable buildings, 120 to 300 m/hr. In rural areas, the fire spreads with a speed of 600 to 900 m/hr and more.

The presence of combustible materials around buildings is also very important. The following materials can be easily ignited by thermal radiation: tar paper, paper, straw, cane reeds, peat, wood, oil products, and other materials. In cities and in [other] populated areas where there are large quantities of such materials, group fires may break out due to the effect of thermal radiation. The ignition of materials by thermal radiation depends on their properties, thickness, and moisture content. The thermal pulse values causing ignition of various materials are listed in Table 5.

It is evident from Table 5 that in a blast with a power of 20 kilotons, thermal pulses are less intense than from a blast of 10 megatons. This is because the duration of thermal pulse is much longer from a blast of 10 megatons than from a blast of 20 kilotons. Table 6 shows the distances from the centers (ground zero) of

[*This is an obvious error, perhaps caused by not correctly converting wind velocities expressed in mph to km/hr.]

Table 5. Thermal pulse required for ignition

Materials	Thermal pulses (cal/cm^2) as a function of explosive power	
	20 kilotons	10 megatons
Newspaper	3	6
Dry weed	4	9
Sparse dry grass	5	10
Pine shavings (yellow)	5	12
Fallen leaves	6	12
Gray cotton cloth	8	16
Yellow broom	8	17
Fallen pine or spruce needles	8	18
Rubber-treated tarpaulin (gray)	15	28
Cottom cloth (white)	15	30
Coarse wool rug (gray)	16	35

Table 6. [Metric units]

Weapon power, q (kilotons)	Thermal pulse (cal/cm^2): 30	25	20	18	16	14	12	10	8	6	4	2
	Distance from ground zero (km)											
20	1.1	1.15	1.25	1.3	1.35	1.5	1.7	1.8	2.0	2.4	2.8	4.0
	0.7	0.75	0.8	0.85	0.9	1.0	1.1	1.2	1.3	1.4	1.7	2.7
50	1.8	2.0	2.2	2.3	2.5	2.7	3.0	3.2	3.5	4.2	5.0	6.5
	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	2.0	2.2	2.7	3.0
100	2.7	2.8	3.1	3.3	3.6	3.9	4.2	4.6	5.0	6.0	7.0	9.0
	1.5	1.6	1.9	2.0	2.1	2.2	2.4	2.7	3.0	3.4	4.2	6.0
200	3.2	3.4	3.7	4.0	4.3	4.7	5.8	6.9	8.0	9.0	10.0	11.0
	1.8	2.0	2.2	2.4	2.5	2.7	2.9	3.2	3.6	4.1	5.2	7.1
500	5.2	5.5	5.9	6.3	6.6	7.0	8.0	9.0	11.0	13.0	15.0	17.0
	2.8	3.0	3.2	3.6	3.8	4.1	4.4	4.8	5.4	6.1	8.1	10.4
1,000	7.7	8.6	8.8	9.0	10.0	11.2	13.6	14.8	15.8	16.6	18.6	26.8
	4.8	4.9	5.1	5.6	6.2	6.8	7.2	7.8	8.6	10.1	14.0	16.6
2,000	9.0	9.5	9.4	10.5	11.0	12.5	15.0	18.0	20.5	23.0	26.0	29.0
	5.3	5.7	5.9	6.4	7.0	7.5	8.4	8.7	10.0	11.3	14.7	18.2
5,000	13.0	13.8	14.5	15.6	16.5	17.5	20.0	23.0	26.0	29.5	33.0	37.0
	7.9	8.4	8.8	9.3	10.0	11.0	11.5	12.2	14.5	17.0	19.7	24.9
10,000	20.6	21.0	22.0	24.6	26.0	28.0	29.0	30.5	33.0	37.0	41.0	51.0
	12.8	13.2	14.0	15.0	16.0	17.0	18.0	19.0	23.0	27.0	29.0	37.0

[English units]

Weapon power, q (kilotons)	Thermal pulse (cal/cm^2): 30	25	20	18	16	14	12	10	8	6	4	2
	Distance from ground zero (miles)											
20	0.7	0.7	0.8	0.8	0.9	0.9	1.1	1.1	1.2	1.5	1.7	2.5
	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.1	1.7
50	1.1	1.2	1.4	1.4	1.6	1.7	1.9	2.0	2.1	2.6	3.1	4.0
	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.0	1.2	1.4	1.7	2.4
100	1.7	1.7	1.9	2.0	2.2	2.4	2.6	2.9	3.1	3.7	4.3	5.6
	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.9	2.1	2.6	3.7
200	2.0	2.1	2.3	2.5	2.7	2.9	3.6	4.3	5.0	5.6	6.2	6.8
	1.1	1.2	1.4	1.5	1.6	1.7	1.8	2.0	2.2	2.6	3.2	4.4
500	3.2	3.4	3.7	3.9	4.1	4.3	5.0	5.6	6.8	8.1	9.3	10.6
	1.7	1.9	2.0	2.2	2.4	2.6	2.7	3.0	3.4	3.8	5.0	6.5
1,000	4.8	5.3	5.5	5.6	6.2	7.0	8.5	9.2	9.8	10.3	11.6	16.7
	3.0	3.0	3.2	3.5	3.9	4.2	4.5	4.8	5.3	6.3	8.7	10.3
2,000	5.6	5.9	5.8	6.5	6.8	7.8	9.3	11.2	12.7	14.3	16.2	18.0
	3.3	3.5	3.7	4.0	4.3	4.7	5.2	5.4	6.2	7.0	9.1	11.3
5,000	8.1	8.6	9.0	9.6	10.9	10.9	12.4	14.3	16.2	18.3	20.5	23.0
	5.0	5.2	5.5	6.1	6.2	6.8	7.1	7.6	9.0	10.6	12.2	15.5
10,000	12.8	13.0	13.7	15.3	16.2	17.4	18.0	19.0	20.5	23.0	25.4	31.7
	8.0	8.2	8.7	9.3	9.9	10.6	11.2	11.8	14.3	16.8	18.0	23.0

NOTE: The first values give the distances [from ground zero] for an air burst; the second values give the distances for a surface burst.

the blast [area] at which thermal pulses of different intensities occur for [different power] surface and air bursts.

The spreading of fires in the city depends on fire-resistant properties of the buildings, their density, local topography, weather conditions, and the distances from the center of the blast.

The building density has an especially great influence on the spreading of fires. The smaller the builtup density, the lower the probability of a fire spreading from one building to another. Figure 18 is a curve expressing in percentages the probability of fire spreading as a function of the distances between buildings.

It is evident from the graph that if the distance between buildings is 15 m, in 50 cases out of 100 the fire will spread to the next building. At distances between the buildings of 90 m, there was zero probability of a fire jumping from one building to another.

Local topography also has an influence on the spreading of fires in a city. The total area of the fires caused by the atomic blast in Nagasaki was four times less than the area of fires in Hiroshima, because the spreading of fires in Nagasaki was hindered by the hilly nature of the area. In Hiroshima, which is built on flat terrain, there were no such impediments. In addition to the relief of the locality, the presence of water obstacles and green areas which modify the effect of the fire and impede its propagation are also very important.

The time of year and the meteorological conditions also have a great influence on the spreading of fires. In bright summer weather, favorable conditions are created for the spreading of fires. Rain, fog, and snowfall attenuate thermal radiation and consequently inhibit the formation of group fires. In industrialized cities, the atmosphere contains large quantities of dust and smoke, forming smog which attenuates thermal radiation. The execution of preventive measures has great importance for preventing group fires.

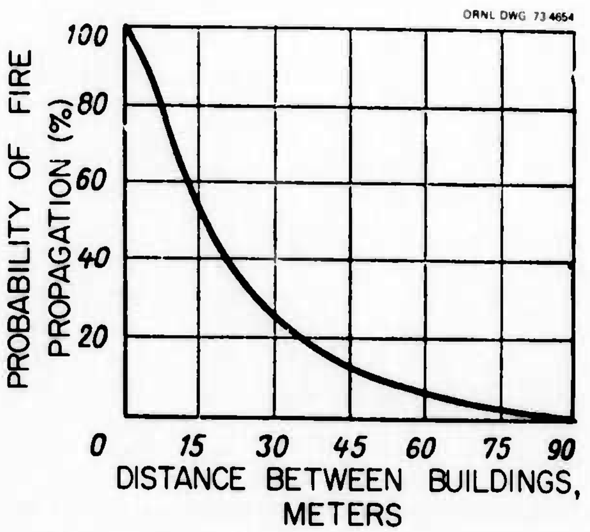

Fig. 18. Probability of fire propagation as a function of the distance between buildings.

As a result of thermal radiation, large forest fires may break out due to the combustion of dry leaves, grass, and dry wood. The propagation of fires in forests depends on the season and meteorological conditions. Coniferous forests in dry summer weather present a particularly great hazard. As a rule, deciduous forests, especially when the leaves have not yet fallen, burn less rapidly and with less intensity than coniferous forests.

The radius of action of thermal radiation is greater than the radius of action of the blast wave. Thus, with a nuclear blast with a power of 1 megaton, the radius of action of the blast wave is 11 km [6.8 miles], and the radius of action of thermal radiation is 17 km [10.5 miles]. Thermal radiation is propagated far beyond the limits of the zone of action of the blast wave.

Initial nuclear radiation. Initial nuclear radiation is a flux of gamma rays and neutrons emitted from the center of a nuclear blast. The source of the initial nuclear radiation is a nuclear reaction and radioactive decay of nuclear fission products. The duration of the effect of initial nuclear radiation does not exceed 10 to 15 sec from the moment of the blast. After this, the decay of short-lived fission fragments formed as a result of the nuclear reaction terminates. In addition, the radioactive cloud rises to great heights, and radiation is absorbed by the mass of air and does not reach the surface of the earth.

Initial nuclear radiation is characterized by absorbed dosage, that is, the amount of energy from the radiation absorbed per unit volume of irradiated media. The exposure dose is a measure of the total amount of ionization that the quantity of gamma rays and neutrons can produce in the air volume. The ionization process consists in knocking out electrons from electron shells of atoms. Due to this, the uncharged atoms, are converted to variously charged particles, ions.

Initial nuclear radiation is the total flux of gamma radiation and neutrons. Gamma radiation, making up the greater part of initial nuclear radiation, is produced immediately at the moment of detonation, in the process of the explosive nuclear reaction, as well as after the blast as a result of radiative neutron capture by the nuclei of atoms of various elements. The duration of gamma radiation is 10 to 15 sec. The unit for measuring a gamma-radiation dose is the roentgen, the special international physical dose unit (amount of energy).

A roentgen is the amount of gamma radiation which, at a temperature of 0°C and a pressure of 760 mm in 1 cm^3 of dry air, produces 1 billion ion pairs (more precisely 2.08×10^9). The roentgen is designated by the letter R. One thousandth part of a roentgen bears the designation milliroentgen and is abbreviated mR.

The neutron flux produced in a nuclear explosion contains fast and slow neutrons which affect living organisms differently. The neutron fraction in a total dose of initial nuclear radiation is smaller than the gamma-ray fraction. It increases somewhat with a decrease in the power of the nuclear blast. The basic source of neutrons in a nuclear blast is the nuclear chain reaction. The neutron flux radiates in fractions of a second after the blast and can cause artificially induced radiation in metal objects on the ground. Induced radioactivity is observed only in the zone directly adjacent to the blast site.

The radiation dose in a neutron flux is measured by a special unit, the roentgen equivalent mammal (rem). The rem is the dose of neutrons with a biological effect equivalent to 1 R gamma radiation.

The harmful effect of initial nuclear radiation on humans is called irradiation, which has a harmful biological effect on living cells of organisms. This harmful effect stems from the fact that gamma rays and neutrons ionize the molecules of living cells. This ionization disrupts the normal activity of cells and in large doses leads to their destruction. The cells lose their power to undergo mitosis; as a result the individual develops radiation sickness.

The effect of initial nuclear radiation on human beings depends on the radiation dose and the exposure time. A single exposure dose of up to 50 R in the course of 4 days and nights, as well as a continuous dose of up to 100 R over 10 days, will not cause pathological symptoms and is not considered dangerous; doses above 100 R cause radiation sickness.

There are three degrees of radiation sickness, depending on the exposure dose: first (light), second (moderate), and third (serious).

First degree radiation sickness is produced by a total dose of 100 to 200 R. The latency period lasts from two to three weeks, when general condition becomes poor with asthenia, nausea, vertigo, and intermittent fever. The white blood cell count decreases. First degree radiation sickness is curable.

Second degree radiation sickness is produced by a total exposure dose of 200 to 300 R. The latency period lasts about one week, after which pathological symptoms appear, like those from first degree radiation sickness, but of greater severity. With good medical treatment, recovery takes about 1½ to 2 months.

Third degree radiation sickness is produced by a total exposure dose of 300 to 500 R. The latency period is reduced to a few hours. The symptoms are more severe; with active medical treatment, recovery takes several months.

An exposure dose greater than 500 R is usually considered fatal.

The dosages of initial nuclear radiation depend on the type and power of the blast and the distance from the center of the explosion. Table 7 gives the radii at which different initial nuclear radiation doses are delivered by explosions of varying force. It is evident from Table 7 that the harmful radius of initial nuclear radiation is much smaller than the radii of destruction of blast waves and thermal radiation (see Tables 4 and 6).

Initial nuclear radiation does not have a noticeable effect on most objects. However, the glass of optical instruments may darken due to its effects, and photographic film in sealed cartridges may become exposed.

Various materials which attenuate gamma rays and neutrons also protect against initial nuclear radiation.

Table 7.

Dose (R)	Radius (km) [miles] TNT equivalent				
	20 kilotons	100 kilotons	1 megaton	5 megatons	10 megatons
500	1.2 [0.7]	1.8 [1.1]	2.4 [1.5]	3.0 [1.9]	3.4 [2.1]
300	1.4 [0.9]	1.9 [1.1]	2.6 [1.6]	3.2 [2.0]	3.6 [2.2]
200	1.5 [0.9]	2.0 [1.2]	2.8 [1.7]	3.4 [2.1]	3.0 [2.4]
100	1.6 [1.0]	2.1 [1.3]	3.0 [1.9]	3.6 [2.2]	4.2 [2.6]

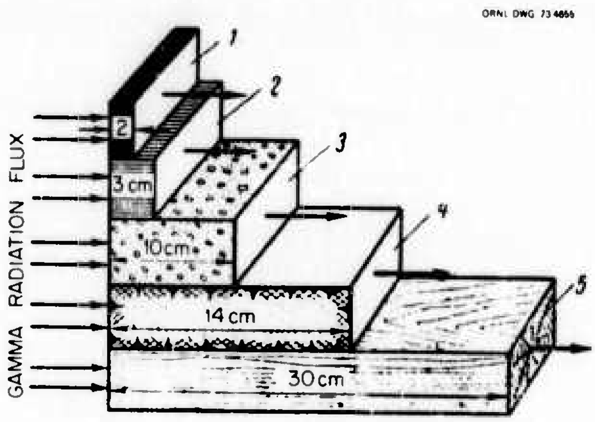

Fig. 19. Relative half-value layer of gamma rays, for different materials: 1 = lead; 2 = steel; 3 = concrete; 4 = soil; 5 = wood.

The degree of gamma-ray attenuation depends on the nature of the materials and the thickness of the absorbing layer. Gamma-ray attenuation is described by the half-value layer, which depends on the density of the materials.

The half-value thickness is the layer of a substance which reduces the intensity of incident gamma radiation by a factor of 2 (Fig. 19). The thickness of this layer is determined according to the formula

$$d_{h\text{-}v} = 23/\rho ,$$

where

$d_{h\text{-}v}$ = the half-value thickness of the layer, cm;

ρ = the density of the material, g/cm^3;

23 = the half-value thickness of the water layer, cm.

The half-value thicknesses of various materials for gamma rays and neutrons [of initial nuclear radiation] are listed in Table 8.

Table 8.

Material	Density, ρ (g/cm^3) [lb/ft^3]	Half-value thickness (cm) [in.]	
		Gamma rays	Neutrons
Lead	11.3 [705.1]	2 [0.8]	9 [3.5]
Steel	7.8 [486.7]	3 [1.2]	5 [2.0]
Concrete	2.3 [143.5]	10 [3.9]	12 [4.7]
Earth	1.6 [99.8]	14 [5.5]	12 [4.7]
Wood	0.7 [43.7]	30 [11.8]	10 [3.9]

It is clear from Table 8 that gamma rays and neutrons are attenuated by materials to a different degree. For more prevalent building materials (concrete and earth), the half-value thicknesses are almost identical, permitting calculations [using] only [the values] for gamma radiation.

To guarantee the effective protection of people from initial radiation, it is necessary to consider its attenuation in protective buildings. The attenuation of initial radiation is otherwise called the shielding coefficient of a building and is designated by the letter K. The shielding coefficient K of a building shows how many times a given building attenuates penetrating radiation. It is determined according to the formula

$$K = \frac{h}{2^{d_{h\text{-}v}}} ,$$

where h is the thickness of the shielding material in centimeters and $d_{h\text{-}v}$ is the half-value thickness in centimeters. The shielding coefficient of a blast shelter amounts to 500 to 1000 or more.

Radioactive contamination [fallout]. Radioactive contamination of land, water, and the atmosphere occurs as a result of fallout of radioactive materials from the cloud of a nuclear explosion. The sources of radioactive materials are: (1) fission products of a nuclear burst, emitting beta and gamma rays; (2) radioactive materials of unfissioned fractions of a nuclear charge (^{235}U or ^{239}Pu), emitting alpha, beta, and gamma rays; (3) radioactive materials produced in earth by neutrons (induced radiation). Under the effect of neutrons, silicon, sodium, and magnesium atoms in the earth become radioactive and emit beta and gamma rays.

However, induced radiation in the ground and radioactive materials of the unfissioned portion of a nuclear charge comprise an insignificant part of all radioactive materials formed in a nuclear blast. Thus, the basic source of radioactive materials is fallout from the radioactive cloud resulting from the nuclear blast. These are a mixture of a large number of isotopes of various chemical elements formed by the nuclear fission process and the radioactive decay of these isotopes. During fission of the nuclei of ^{235}U and ^{239}Pu, about 200 isotopes of 36 different elements are formed.

Properties of radioactive materials. Fallout radiation from the cloud of a nuclear blast has no features that the senses can detect: color, taste, or smell. With long half-lives, they emit alpha, beta, and gamma rays during decay. These emissions have different properties.

Alpha rays are high-speed helium nuclei consisting of two protons and two neutrons. The escape velocity of an alpha particle reaches 20,000 km/sec, and its mean free path length in air does not exceed 10 cm. A sheet of paper or [ordinary] clothing is sufficient to absorb alpha particles. Alpha-active particles are dangerous when they penetrate an organism because the alpha rays emitted by them cause strong molecular ionization which damages the internal organs.

Beta rays are fast electrons with velocities up to 250,000 km/sec and mean free path lengths in air of up to about 10 m. The ionizing power of beta particles is 100 times lower than that of alpha particles, but their penetrating power is greater; thicker absorbers are required for them. An aluminum sheet of 1 mm thickness effectively shields against beta rays. Beta-active materials are dangerous when they fall on the skin and reach the internal organs, since irradiation of internal organs is much more dangerous than external irradiation.

Gamma rays are electromagnetic rays with a wavelength of 3×10^{-9} cm and a velocity of 300,000 km/sec; their mean free path length in air attains 100 m. The ionizing power of gamma rays is 1000 times weaker than that of alpha rays; however, gamma rays are highly penetrating, and much thicker materials are needed to attenuate them. Thus, gamma rays are more dangerous.

Spontaneous disintegration and conversion of all nuclei of a given element does not take place chaotically but according to the law of radioactive decay. The length of its half-life is used to describe the radioactive disintegration of an element. The half-life T is the time during which one-half of the atoms which existed at the start of the interval disintegrate. The half-life of a given radionuclide is always the same and cannot be changed by any external influence. If we assume N_0 to be the number of atoms, then after passage of one half-life the remaining half would equal $N_0/2$. The disintegration characteristics are shown in Fig. 20.

Depending on the characteristics of the radionuclides, the half-life of different isotopes may be from a fraction of a second to billions of years. For example, the half-life of ^{238}U is 4.5 billion years, ^{235}U 707 million years, ^{60}Co 5.3 years, and ^{3}H 12 years.

Radioactive contamination of an area is measured in roentgens per hour (R/hr) and is referred to as the radiation level. The radiation level indicates the exposure dose which a person in a contaminated area may receive in a unit of time (hour). An area is considered contaminated if the radiation level is 0.5 R/hr and higher.

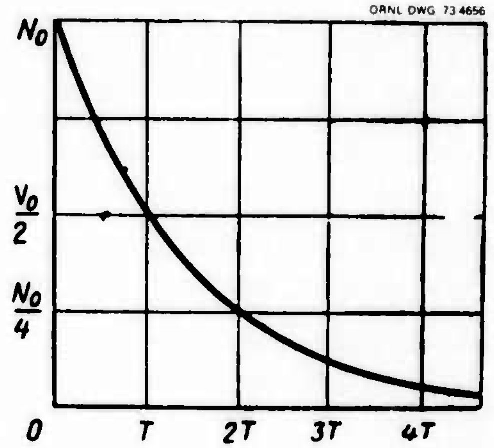

Fig. 20. Law of radiation decay: T = half-life, N_0 = number of atoms at start of half-life.

Contamination of objects equipment, and human skin is measured in milliroentgens per hour (mR/hr) or in beta decays per minute on 1 cm² of area (beta decays/min × cm²). Contamination of food supplies is measured in milliroentgens per hour, in beta decays per minute on 1 cm² of the surface of the product, or in beta decays per minute per gram of the product. Contamination of water is measured in volumetric units in milliroentgens per hour and in curies per liter (Ci/l). A curie is the quantity of a radioactive material in which 37 billion (3.7×10^{10}) atomic disintegrations occur per second; it describes the radioactivity of a given material.

The contamination of an area by radioactive material depends on the power and type of burst (air, surface, underground), the direction and force of the wind, the character of the area and the earth, and meteorological conditions. The degree of contamination in an area is determined primarily by the power of the blast. The more powerful the blast, the more radioactive products are formed, and the more the area is contaminated. In addition, the type of explosion is very important. Especially heavy contamination occurs with a surface burst.

The relief of the terrain and the soil conditions influence the uniformity of radioactive contamination. The degree of contamination of an area is approximately uniform only on a plain at equal distances from the blast center and from the axis of the cloud track in the absence of wind. On very broken ground, radioactive materials may be slowed down by slopes with sides exposed to the wind. In the city, radioactive contamination is distributed irregularly due to the irregularity of the buildings.

Meteorological conditions, especially precipitation, have a great influence on the radiation level in a given area. In a ground blast, the wind causes the contamination of a large territory, since large amounts of radioactive material are carried by the wind and then settle to the ground. Strong wind also increases the dissemination of radioactive material over a wide area. Because the radioactive cloud is transported by a strong wind to great distances from the site of the explosion, the radiation level at the blast site declines.

Cloudiness may lead to radioactive rain, increasing the radiation level. Radioactive material falling into rain clouds favors droplet formation, condensation, and rainfall. Rain promotes rapid precipitation of radioactive materials on the ground since raindrops entrap fine dust particles and carry them earthward. In addition, however, heavy rainfall after a blast washes the radioactive substances from the surface of the earth.

Snowfall, as well as rain, causes rapid fallout of radioactive material to the ground, and contamination of the area increases; but a large amount of snowfall after contamination forms a layer which attenuates the radioactivity.

Fog and humidity promote radioactive fallout, and contamination of the area increases.

Characteristically, the level of radioactive contamination drops steadily with time due to the decay of the radioactive fallout from the cloud of a nuclear explosion. A tenfold decrease in the radiation level is observed with a sevenfold increase in time. Thus, if the radiation level is defined as 100% at 1 hr after the nuclear blast, then after 7 hr it will amount to about 10%, 1% after 7^2 hr (49 hr, about 2 days and nights), and about 0.1% after 7^3 hr (343 hr, or about 2 weeks).

As an example, let us examine the regularity in the drop of the radiation level. When measured 1 hr after the blast, the radiation level was 1000 R/hr; after 1 hr, 1000 R/hr; after 7 hr, 100 R/hr; after 2 days and nights, 10 R/hr; after 2 weeks, 1 R/hr. Thus, two weeks are required for the radiation level to decrease from 1000 to 1 R/hr. This law of radioactivity decay permits us to determine the radiation level per unit of time (seven times per unit of time). Table 9 shows the radiation level at varying times after the blast.

Damage from radioactive materials involves two factors: contamination and human exposure. Within the contaminated area, people are exposed to gamma rays and contamination from radioactive materials settling on clothing and skin (external contamination) and also to radioactive materials which enter the body by ingestion of food and drink (internal contamination). Human contamination by radioactive material, as well as a prolonged residence time in a contaminated area, produces an exposure which may cause radiation sickness. Exposure doses causing radiation sickness are the same as those for initial nuclear radiation: a single dose greater than 50 R is considered dangerous.

Table 9.

Time after blast	Dose rate (R/hr)																				
30 min	2.3	4.5	9.1	13	18	23	45	68	91	114	136	182	227	456	546	681	908	1140			
1 hr	1.0	2.0	4.0	6.0	8.0	10	20	30	40	50	60	80	100	200	240	300	400	500	600	800	1000
1.5 hr	0.6	1.2	2.4	3.7	4.9	6.1	12	18	24	31	37	48	61	122	146	183	244	305	366	468	610
2 hr	0.4	0.9	1.8	2.6	3.5	4.4	8.7	13	18	22	26	35	44	87	105	131	175	219	266	350	437
3 hr	0.3	0.5	1.1	1.6	2.1	2.7	5.4	8.0	11	13	16	21	27	54	64.4	80	107	134	161	214	268
5 hr		0.3	0.6	0.9	1.2	1.5	2.9	4.4	5.8	7.3	8.7	12	15	29	35	44	58	73	87	116	145
7 hr			0.4	0.6	0.8	1.0	1.9	2.9	3.9	4.9	5.8	8	10	19	23	29	39	[illegible]	58	78	97
10 hr				0.4	0.5	0.6	1.3	1.9	2.5	3.2	3.8	5.1	6.4	13	15.4	19	25	32	38	51	64
15 hr					0.3	0.4	0.8	1.2	1.6	1.9	2.3	3.2	3.9	7.8	9.5	12	16	19	23	31	39
1 day							0.5	0.7	0.9	1.2	1.3	1.8	2.3	4.5	5.4	6.8	9.0	12	13	18	23
1.5 days							0.3	0.4	0.6	0.7	0.9	1.2	1.5	2.9	3.5	4.4	5.8	7.3	8.7	12	15
2 days									0.4	0.5	0.6	0.8	1.0	1.9	2.3	2.9	3.9	4.9	5.8	7.8	10
4 days												0.3	0.4	0.8	1.0	1.3	1.7	2.1	2.5	3.3	4.2
1 week														0.5	0.6	0.7	0.9	1.2	1.4	1.8	2.3
2 weeks																	0.3	0.4	0.5	0.6	0.8
4 weeks																				0.3	0.4

To protect people from radioactive contamination, hermetically sealed blast shelters and fallout shelters are built and equipped with filter systems.

Industrial buildings which will not interrupt their manufacturing activities under the threat of fallout are built to guarantee partial sealing in the case of contamination of the area and the air, considering the attenuation factor for fallout radiation of buildings and structures.

Individual protective devices are used to protect people from radioactive materials (gas masks, protective clothing), and the safe exposure period is monitored in a contaminated area to be sure that the dose does not exceed 50 R. After leaving the radioactive zone, it is necessary to remove the radioactive materials deposited on clothing and the skin, that is, proceed with sanitary measures and decontamination of clothing.

2.1.3 Secondary Damaging Effects

The damaging effects of a nuclear blast cause destruction and fires, which in turn may cause secondary damage; [for example] initial nuclear radiation generates electromagnetic waves which affect electronic instruments.

If petroleum-extracting and -refining equipment is damaged, fires and explosions are caused on a scale which may exceed the immediate effect of the nuclear blast. Damaged chemical plants may cause local contamination, while destruction of a hydroelectric installation may cause flooding of populated areas.

In addition, nuclear blasts create electromagnetic fields, which generate surges in underground lines and in high-wire lines and radio station antennas, and also generate radio waves propagated over a wide area. The induced current and voltage may be propagated by wires over a wide area and cause damage to insulation, electrical and radio equipment may burn out, and personal injuries may occur. It is necessary to expedite municipal technical defense measures to provide protection from secondary damage.

2.2 AREAS OF NUCLEAR DAMAGE AND ZONES OF RADIOACTIVE CONTAMINATION

An area of nuclear destruction is an area subjected to the direct effect of a nuclear blast. The boundary of such an area is arbitrarily defined as the line where the overpressure of the blast wave reaches 0.1 kg/cm² [~1.5 psi]. To determine the possible nature of the destruction and also the necessary amount of rescue and temporary emergency restoration work, an area of nuclear destruction is divided into four zones (Fig. 21).

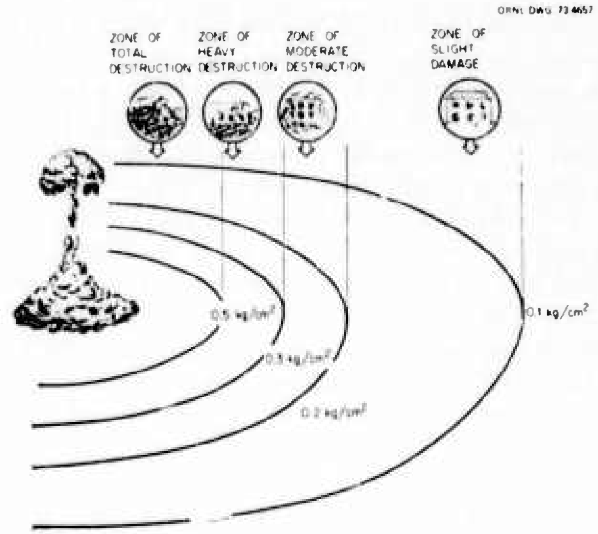

Fig. 21. Zones in an area of nuclear destruction.

The zone of complete destruction is characterized by an overpressure exceeding 0.5 kg/cm² [~7 psi] in the blast wave front. In this zone, residential and industrial buildings are completely destroyed; fallout shelters and some of the blast shelters located near ground zero are also destroyed. The majority of the blast shelters (up to 75%) and underground utility lines (up to 95%) remain undamaged. The streets are completely clogged due to the destruction of buildings. Entrances and exits of built-up shelters are blocked. Fires do not occur in zones of complete destruction; flames due to thermal radiation are prevented, because rubble is scattered and covers the burning structures. As a result the rubble only smolders, and fires as such do not occur. In zones of complete destruction, rescue work is carried out under complex conditions and involves clearing away the rubble, rescuing people from obstructed shelters, and particularly supplying air to shelters in which the filtering system has been destroyed.

A zone of heavy destruction is one in which the overpressure in a blast wave front amounts to 0.5 to 0.3 kg/cm² [7 to 4 psi]. In this zone the buildings and structures sustain heavy damage, but the shelters and the power lines remain intact. The majority of basement-type fallout shelters are also undamaged. A layer of rubble is formed as a result of damaged buildings. Conflagrations result from thermal radiation. The basic rescue work in this zone consists of clearing away the rubble and rescuing people from blocked blast shelters and fallout shelters and from destroyed and burning buildings.

The zone of moderate destruction is characterized by an overpressure in a blast wave front from 0.3 to 0.2 kg/cm^2 [4 to 3 psi]. In this zone, the buildings sustain moderate damage, while blast shelters and fallout shelters are completely undamaged. Local rubble is produced as a result of destroyed buildings.

The zone of slight destruction is characterized by an overpressure of 0.2 to 0.1 kg/cm^2 [3 to 1½ psi]. In this zone buildings sustain slight damage (partitions, doors, and windows are damaged); as a result isolated rubble may be present. Isolated fires may occur due to thermal radiation. The basic rescue work in this zone is to extinguish fires and rescue people from partially destroyed and burning buildings.

Beyond the zone of slight destruction, the shock wave is practically harmless to unprotected people. Buildings may undergo insignificant damage (damage to glass, roofs, and door and window frames). In addition, isolated fires may arise. People may experience slight injuries. Beyond the zone of slight damage, people are able to aid the injured and clear away the damage without assistance.

The area of destruction may be thought of as a circle and [its area] is calculated according to the formula

$$A = \pi R^2 ,$$

where R is the radius of destruction with an overpressure of 0.1 kg/cm^2 [1.5 psi], determined according to Table 4, or calculated.

Example: The radius of destruction (0.1 kg/cm^2 [1.5 psi]) of a 10 megaton nuclear weapon equals 25 km. We need to determine the area of destruction.

Solution:

$$\text{Area of destruction} = \pi R^2 = 3.14 \cdot 25^2 = 1962.5 \text{ km}^2 .$$

The area of the zone of nuclear destruction is determined according to the formula:

zone of complete destruction (area of a circle)

$$A_1 = \pi R_1^2 ,$$

zone of heavy destruction (area of a ring)

$$A_2 = \pi(R_2^2 - R_1^2) ;$$

zone of moderate damage (area of a ring)

$$A_3 = \pi(R_3^2 - R_2^2);$$

zone of slight damage (area of a ring)

$$A_4 = \pi(R_4^2 - R_3^2) .$$

The radius in which injury of people and destruction of buildings occur from the blast wave of a nuclear explosion may be determined with the aid of tables and graphs, as well as by the law of similarity of explosions.

2.2.1 Law of the Similarity of Explosions

As theoretical studies have shown, the radii of the zones of destruction and damage from a blast wave of nuclear and thermonuclear explosions of different force are proportional to the cube root of the ratio of TNT equivalents. Thus, for an approximate comparison of the radii of zones of destruction of a shock wave from nuclear blasts of varying powers, we may use the formula

$$\frac{R_2}{R_1} = \sqrt[3]{\frac{q_2}{q_1}} ,$$

where R_1 and R_2 are the radii of the zones of destruction in meters and q_1 and q_2 are the TNT equivalents in kilotons.

Example: The radius of slight damage in an air burst with a power of 20 kilotons is 3200 m. To determine the radius of destruction of a nuclear blast with a power of 10 megatons, substitute the known values in the formula referred to above:

$$R_2 = R_1 \sqrt[3]{\frac{q_2}{q_1}} = 3.2 \sqrt[3]{\frac{10{,}000{,}000}{20{,}000}} \cong 25 \text{ km [15 miles]} .$$

It is clear from this example that with a 1000-fold increase in the TNT equivalent of a nuclear bomb the radius of destruction increases 10 times. Thus, the area of nuclear destruction is characterized by:

1. massive injury to people and animals;
2. damage and destruction of surface buildings and structures;
3. partial damage, destruction, or collapse of CD shelters;
4. occurrence of individual and group fires and conflagrations;

5. continuous and scattered rubble in the streets, thoroughfares, and alleys;
6. massive damage to networks of the utility services;
7. formation of zones and bands of radioactive contamination from surface bursts.

2.2.2 Zones of Radioactive Contamination

Zones of radioactive contamination form in the center as well as beyond the limits of the area of nuclear destruction after surface bursts. A great quantity of radioactive products is formed by a nuclear explosion; these products are carried to great heights in the mushroom cloud. Part of the radioactive materials settles to the surface of the earth in the course of about 1 hr after the blast, forming a zone of contamination in the blast area, extended in the direction of the wind.

A radioactive cloud, formed by a surface burst, is transported by the wind. Radioactive materials fall from the cloud, leaving on the surface of the earth an invisible trail of radioactive contamination which follows the movement of the cloud. The trail may be visualized as drawn by the wind along a band of contamination of approximately elliptical shape. The imaginary line which can be drawn down its center is called the axis of the trail. The ellipse of contamination is characterized by length R and width L.

The size of the zone of radioactive contamination depends on the explosive power, wind velocity, meteorological conditions, and topography. The approximate dimensions of the band of contamination with a marginal dose rate of 0.5 R/hr and a wind velocity of 50 km/hr (31 mph) may be as follows: in a nuclear blast of 20-kiloton power, width 10 km [6.2 miles] and length 60 km [37 miles]; in a nuclear blast of 10-megaton power, width 60 km [37 miles] and length 800 km [496 miles].

Radioactive fallout continues for some time at each point in the contamination band, while the radioactive cloud passes over. Radioactive material contaminates the area irregularly, the strongest contamination being observed near ground zero of the blast, while lower radiation levels are found further from the blast site (Fig. 22).

Radioactive products of nuclear explosions do not settle immediately over the entire band, but do so gradually, with the forward movement of the cloud, and initiation of contamination depends on the wind velocity. For example, with a moderate wind velocity of 50 km/hr [31 mph] at a distance of 600 km [372 miles] from ground zero of the blast, radioactive fallout begins about 12 hr after the blast. After this time, the

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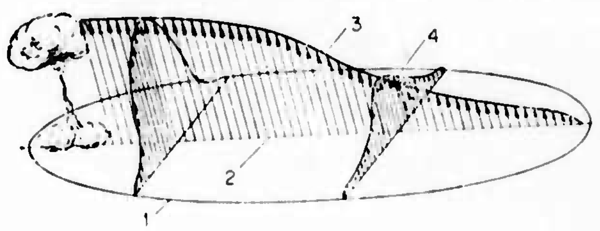

Fig. 22. Dose rate distribution along the trail of a radioactive cloud: 1 = track of the radioactive cloud; 2 = axis of the track; 3 = dose rate along the axis of the track; 4 = dose rate transverse to the track.

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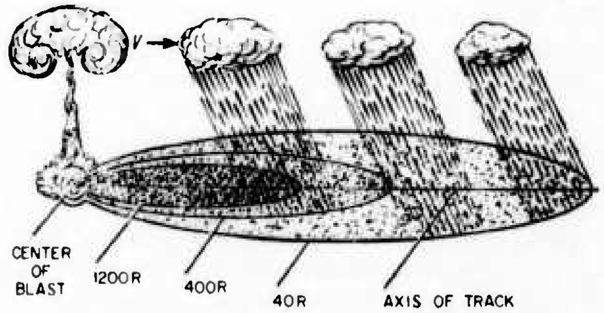

Fig. 23. Zones of radioactive contamination on terrain.

wind direction may change and with it the direction of cloud movement. The direction of the track of radioactive contamination also changes.

A zone of contamination is characterized by exposure doses and dose rates. A radiation dose from all of the fallout [infinity dose] D_∞ of the radioactive substances is taken as a basis. A person who stays in the open until all the radioactive material decays will receive such a dose. The zone of contamination can be arbitrarily divided into three zones (Fig. 23): zone A, moderate contamination; at the periphery the exposure dose is $D_\infty = 40$ R; the dose rate 1 hr after the blast is 8 R/hr, and after 10 hr it is 0.5 R/hr; zone B, high level contamination; at the periphery the exposure dose is $D_\infty = 400$ R; the dose rate 1 hr after the blast is 80 R/hr, and after 10 hr it is 5 R/hr; zone C, dangerous contamination; at the periphery the exposure dose is $D_\infty = 1200$ R; the dose rate 1 hr after the blast is 240 R/hr; after 10 hr it is 15 R/hr.

Thus the region of radioactive contamination presents a danger to people who may receive the maximum exposure dose and may be contaminated by radioactive materials if they do not take protective measures.

2.3 CHEMICAL WEAPONS

2.3.1 Characteristics of Chemical Weapons

A chemical weapon is a toxic material (TM) and the means by which it is delivered. The toxic materials, chemical compounds, are the primary active agents of a chemical weapon. The toxic material is distinguished from other harmful agents by its damaging characteristics. Such materials can penetrate with the air into buildings, dwellings, and production facilities, as well as into protective structures which are not hermetically sealed; they can be harmful to the occupants. They may retain their harmful effect in the air, on open terrain, and on various objects for a long period of time. Dispersed in large volumes of air and over wide areas, they affect all people within their range of potency who do not seek shelter facilities. Gaseous toxic materials can be propagated in the wind direction great distances from areas where the chemical weapons were directly applied.

The most important characteristic of toxic materials is their high toxicity, that is, their power to cause damage when they enter an organism in minimal doses. Injury from toxic material may occur as a result of breathing contaminated air; having it come in contact with the eyes, the skin, or clothing; ingesting contaminated food or water; or as a result of coming into contact, unprotected, with contaminated objects. But the toxic materials in the air can affect people only in so-called combat concentrations or densities.

The concentration is the amount of toxic material per unit volume of contaminated air, usually expressed in weight units, that is, milligrams of TM per liter of air, or in grams of TM per cubic meter of air. For example, a phosgene concentration of 0.5 mg/liter means that 1 liter of contaminated air contains 0.5 mg of phosgene. If the toxic material is sprayed on the ground in the form of liquid droplets, then its weight per unit of surface area is called the contamination density and is expressed in grams per square meter. For instance, a contamination density of 15 g/m^2 means that there is an average of 15 g of TM on one square meter of contaminated area.

The harmful effect of the toxic material on an organism may be local or general. In a local effect, the injury appears in areas where the organism has had direct contact with TM – on the skin, mucous membranes of the upper respiratory tract, eyes, respiratory system, and the digestive organs. In a general effect, the damage (toxic effect) usually appears after the toxic material has entered the blood stream, which carries it to other organs. The toxic material may enter the blood stream and cause general poisoning as a result of absorption from the skin (skin absorption toxicity) or from the respiratory organs (inhalation toxicity). General poisoning may result from ingestion of food and water which have been contaminated with toxic materials.

Local and general effects of toxic materials cannot be considered separately; these concepts are arbitrary to a certain degree. If the TM accumulates, a local process may become a general toxic process. However, a local effect is symptomatic primarily of a few toxic materials; in the case of other agents, general intoxication is produced. Simultaneous local and general effects are possible.

Toxic materials have definite physicochemical and toxic properties, a knowledge of which allows a more rational organization of chemical warfare protection of the population. Such properties as boiling and freezing points, volatility, specific gravity, solubility, and viscosity are of great practical importance. Knowledge of a given TM's boiling point, viscosity, and volatility make it possible to determine approximately how long that TM will survive at a certain place, that is, how long contamination will last. Solubility and specific gravity can be used to judge the degree of contamination of a liquid and the possibility of washing the TM from contaminated surfaces.

A knowledge of the chemical properties of poisonous substances makes it possible to select the means and methods for detecting (indicating) and decontaminating (neutralizing) TM. The properties of toxic materials are generally divided into groups for study according to functional stability relative to maintaining their toxic effects and the nature of the effect on the human organism. In the armies of capitalistic countries, TM are arbitrarily divided into persistent and nonpersistent.

The persistence of a TM is its power to retain its harmful effect for a determined period of time after it is used; this depends on the physical and chemical properties of the TM, the method with which it was applied, meteorological conditions, and the character of the territory where it was released. Persistent toxic materials retain their harmful effect for a few hours up to several days or even a week. They are modified little by air and humidity and evaporate very slowly. Nonpersistent toxic materials maintain their harmful effects on open terrain for several minutes and in sites of stagnant air (in basements, closed premises, ravines, etc.) for 10 min up to an hour and more.

2.3.2 Basic Characteristics of Toxic Materials

Toxic materials are divided into four groups according to the nature of the effect (toxic effect) on human organs: nerve-paralysis, skin abscesses, general toxicity, and suffocation. The TM classifications used in the armies of capitalistic countries are shown in Table 10. The basic properties of the toxic materials indicated above are given in Appendix I.

Table 10.

Name of TM	Toxic effect	Stability
Sarin	Nerve paralysis	STM
Soman	Nerve paralysis	
V gases	Nerve paralysis	
Mustard gas	Skin irritant	
Prussic acid	General toxicity	UTM
Phosgene	Suffocation	

In the U.S., work is being carried out on a new type of TM, which is called the psychochemical TM. Only small doses (less than 0.001 mg) of these TM are required to incapacitate a human. The effect of the psychochemical TM on people is not fatal, but only psychological. People exposed to these TM become incapable of working for a period of time and lose their self-control. When psychochemical TM's are used, for example, diethylamides of lysergic acid, intoxication and depression set in after about 30 min, causing hallucinations. The effect of this TM lasts from 0.5 to 12 hr (Dr. Rothschild, *Tomorrow's Weapons*, Military Press, 1966) [see footnote *].

Tremorine and psilocybin have been described in the foreign press under the title "fear gases." When the effect of these TM was demonstrated in a cat which had inhaled the particular agent, it ran away from a mouse. In addition to the enumerated substances, in capitalistic countries there is a TM with a lacrimatory and an irritant action which is used to combat demonstrations and in colonial wars (U.S.A. in Vietnam).

2.3.3 Methods for Applying Toxic Materials

To contaminate national economic installations, the enemy may apply poisonous substances with the aid of bombers (bombs, VAP), rockets, and blimps. The bombers of the U.S.A. have aerial chemical bombs in their armaments (ACB) as well as aircraft spray tanks.

[*In the U.S., *Tomorrow's Weapons*, by J. R. Rothschild, McGraw-Hill, 1964.]

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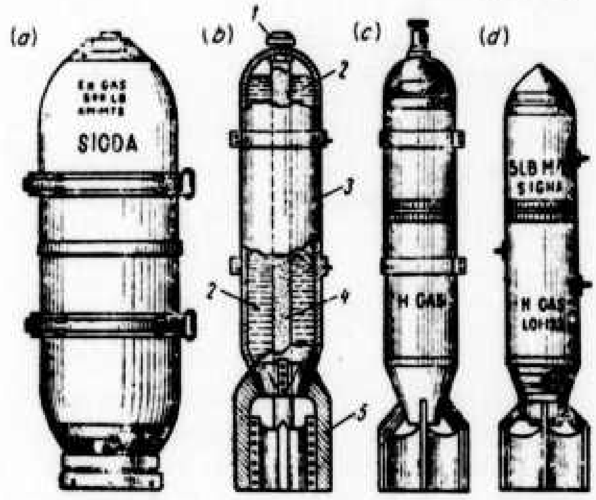

Fig. 24. Aerial chemical bombs: *(a)* Bombs armed with persistent TM; *(b,c,d)* bombs armed with nonpersistent TM. 1, fuse; 2, toxic material; 3, shell; 4, explosive; 5, stabilizer.

The size of U.S. airborne bombs ranges from 4.5 to 450 kg (Fig. 24). Depending on the type of fuse, the aerial chemical bombs may have a [direct] impact effect or a remote effect. The former explode upon contact with the ground or with other objects; the latter may explode at a preset altitude.

Chemical bombs may contain persistent as well as nonpersistent TM. Bombs armed with nonpersistent toxic materials are intended to injure people and contaminate the air; they are equipped with contact fuses. They explode when they strike the ground (or another target) and form a cloud of TM, which is dispersed by the wind over great distances.

Bombs with nonpersistent TM are usually large, 250 to 1000 kg [550–2200 lb], and produce a high concentration of toxic materials over a considerable area at the moment of explosion. For example, a 250-kg U.S. bomb armed with phosgene forms a cloud of contaminated air with a diameter of 50 m and a height of 10 m, with a very high TM concentration; the cloud is propagated by the wind at a dangerous concentration over a considerable distance; the crater usually retains an accumulation of incompletely vaporized TM, the vaporization of which may continue for an hour or more.

Bombs armed with persistent TM are intended to injure people as well as to contaminate the area and targets. Depending on the targets selected by the enemy, remote action bombs may be used. These bombs may be detonated at an altitude of 50 to 200 m, and the toxin will settle on the ground in the form of

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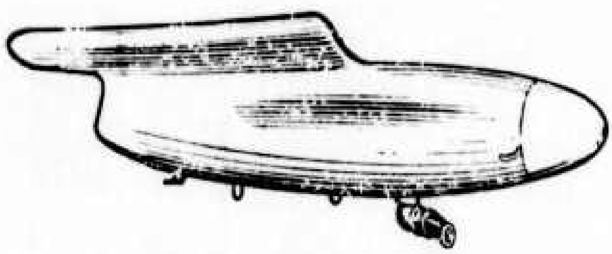

Fig. 25. Aircraft spray tanks (AST).

rain, contaminating the area and targets as well as the population. The size of the contaminated area depends on the size of the bomb, the quantity and quality of the TM, the altitude of the blast, and wind velocity. The size of such bombs may be 100 to 1000 kg. When a 250-kg bomb explodes at an altitude of 100 m, an area of about 5000 m^2 is contaminated with a TM density of 10 to 15 g/cm^2.

Aircraft spray tanks (Fig. 25) are thin-walled metal containers with a streamlined shape; their capacity is several hundred liters. Two to four, depending on the carrying capacity of the airplane and the capacity of the containers, are mounted on the wing surfaces or under the fuselage of aircraft. These cannisters contain TM which discharges from the container as soon as it is dropped and settles on the ground in droplet form; it contaminates the earth and injures unprotected personnel in the area.

The size of the contaminated area when aircraft spray tanks are used depends on the altitude and the flying speed of the aircraft, the duration of spraying, the amount of TM dispensed, and the wind velocity and direction.

Rockets, including ballistic missiles, may be used to apply toxic materials. The special features of this method of attack are the range of delivery and the surprise factor, in addition to which "one large rocket with TM can affect 30% of the people located in an area of about three square kilometers" (Dr. Rothschild, *Tomorrow's Weapons*, Military Press, 1966). [See footnote on page 39.]

2.3.4 Danger Areas of Chemical Contamination

A danger area of chemical contamination is an area subjected to the effects of TM, as a result of which people and animals may be injured. The size of the danger area of chemical contamination depends on the quantity of TM used, the type, the meteorological conditions, and the relief of the terrain.

Persistent TM may be used to form a danger area of chemical contamination. Such an area is capable of sustaining its harmful effect for an extended period of time. The possibility of contaminating an area from the air and consequently creating a danger area of chemical contamination is determined by U.S. specialists according to the lifting capacity of the airplane. By their calculations, one airplane carrying about 7 tons of chemical bombs armed with toxic materials with a nerve-paralyzing effect can create a lethal concentration of TM in an area of 250 km^2 [96 square miles].

If aircraft spray equipment is used, a low-flying plane at a speed of 480 km/hr equipped with two 30-gal (136.5-liter) aircraft spray tanks can contaminate a strip 270 to 360 m wide ("Colliers," September 27, 1953; "Passive Defense, Washington"). The width of the contaminated strip in this case depends on the wind (its velocity and direction) and on the altitude at which the TM was dispensed. Thus, U.S. aviation has the means to create a danger area of chemical contamination. These danger areas will be characterized by massive injury to unprotected people and animals due to contamination by toxic materials of objects, buildings, equipment, transportation, water sources, reservoirs, food supplies, and forage.

Vapors and aerosols are formed when the chemical weapon explodes; the TM's contaminate the air and create a "primary cloud" of contaminated air, which, propagated in the direction of the wind, is capable of injuring people in an area several times larger than the area directly affected by chemical weapons.

When the chemical weapon explodes, some of the TM settles on the ground and on objects in the form of drops (fogging) and when these evaporate a "secondary cloud" of contaminated air is formed which moves in the wind direction and can cause injury to people. Consequently, a danger area of chemical contamination includes territory which is damaged directly by dispersion of TM from weapons and also the territory on which TM vapor is dispersed in combat concentrations, that is, concentrations capable of causing injury to people.

The configuration and size of a danger area of chemical contamination depends on the type of TM substance, the type and quantity of the means of delivery, meteorological conditions, and the character of the terrain. This danger area can be divided into two zones: I, the zone directly contaminated by TM, and II, the zone into which TM vapors and aerosols are dispersed (Fig. 26). The size of zone II, that is, the zone into which TM vapors are dispersed, exceeds zone I several times, especially for such TM as sarin and

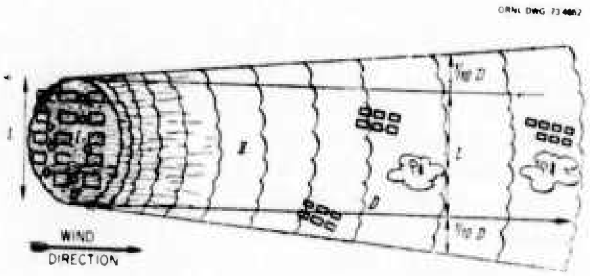

Fig. 26. Danger area of chemical contamination. D = length of TM propagation zone; 1 = width of the zone of direct contamination.

soman. If there is an inversion (and other favorable conditions for using TM), a dangerous concentration of sarin can be propagated for a distance of 15 to 20 km [9–12 miles].

In the case of chemical attack and formation of danger areas of chemical contamination, the basic conditions for guaranteeing functional stability of industrial plants would be to carefully seal production buildings and technological processes and to provide the workers with individual means of protection.

2.3.5 Influence of Meteorological Conditions and Topography on a Danger Area of Chemical Contamination

Meteorological conditions, the relief of the terrain, and the building density have a great influence on the condition of an area of chemical contamination. The temperature and the wind have an important influence on the evaporation rate of TM. When there is intense heating on the earth's surface and a low layer of air, mixing of the lower and upper atmospheric layers occurs and causes rapid dispersion of TM, which evaporates from the ground and objects, while the wind facilitates scattering of these vapors.

At low winter temperatures, TM evaporation will be insignificant; thus, local and material contamination will be more extensive. The vertical stability of the lower atmospheric layers influences the propagation velocity and the area of the TM vapors and thus the size of the secondary danger area of chemical contamination.

It is possible to distinguish three levels of stability in the surface layer of air: the first level is inversion (at which the lower layer of air is cooler than the upper); the second level is isothermal condition (characterized by the fact that the air temperature within 20 to 30 m from the ground is nearly uniform); the third level is convection, when the lower air layer is warmer than the upper layer and vertical mixing occurs. Inversions and isotherms contribute to maintaining a high TM concentration in the surface air layer; they facilitate the dispersal of contaminated air great distances from the contaminated area. Convection causes rapid dispersal of contaminated air, and air concentrations of TM vapors decrease rapidly.

The wind velocity influences the atmospheric TM concentration. With a gentle wind, contaminated air is dispersed slowly, and high concentrations are sustained longer; strong, gusty winds rapidly disperse the contaminated air. With an increase of wind velocity, the TM evaporated from the contaminated area also increases. Heavy rainfall washes the toxic materials from the soil and also lowers the contamination density in the area. Vegetation (underbrush, forests, thick grass), building density, and the relief of the terrain (ravines, gullies) facilitate stagnation of contaminated air and increase the duration of contamination of an area.

2.4 BIOLOGICAL WEAPONS

2.4.1 Concepts Concerning Pathogenic Microbes and Toxins

A biological weapon is a pathogenic microbe or toxin intended to injure people, animals, plants, and food supplies, as well as the material with which these are applied. The basis of the biological weapon is the pathogenic microbe and the toxins which are produced by some microbes. The concept "biological weapon" can be much wider, including not only pathogenic microbes and toxins but also their vectors (insects, ticks, rodents), agricultural pests, and other biological agents.

Depending on their structure and biological characteristics, microbes are classified into bacteria, viruses, rickettsia, and fungi. Bacteria are microorganisms of the plant kingdom, primarily unicellular, visible only under a microscope. Their size ranges from 0.05 to 5 μ [microns]. Under favorable conditions they multiply by simple division very rapidly – every 20 to 30 min. Bacteria are rapidly destroyed by light rays, disinfectants, and boiling. Some forms of bacteria (malignant anthrax, tetanus) are transformed into spores with great stability to the above-mentioned agents. Bacteria are resistant to low temperatures and freezing. Bacteria cause diseases such as bubonic plague, cholera, anthrax, etc.

Viruses are the smallest organisms, a hundred thousand times smaller than bacteria, and they can be detected only with the aid of an electronmicroscope.

Unlike bacteria, viruses multiply only in vivo. They are resistant to drying and freezing. Viruses are responsible for smallpox, yellow fever, etc.

In size and shape, rickettsia approximate some bacteria, but they reproduce and survive only in infected tissue. Rickettsia cause typhus, Q fever, and other diseases.

Fungi, just as bacteria, are in the plant kingdom, but have a more highly developed structure. The resistance of fungi to the effects of physicochemical factors is much higher; they are resistant to desiccation and sunlight.

Toxins are highly active poisons produced by some microbes, for example, by the organisms of botulism, tetanus, and diptheria. The toxins of these microbes are extremely potent and cause serious poisoning. In their most potent form, the toxins retain their potency for many weeks and even months. About a thousand pathogenic microbes are presently known which cause damage to people, animals, and plants. But according to information of the foreign press, they may all be used in a war in the capacity of biological weapons.

United States specialists have selected the following pathogens to destroy humans in a biological war:

1. Bubonic plague, malignant anthrax, melioidosis, brucellosis, tularemia, cholera;
2. Smallpox, equine encephalomyelytis, dengue fever, yellow fever, psittacosis;
3. Typhus, Q fever, Rocky Mountain spotted fever, tsutsugamushi disease;
4. Coccidial mycosis, nocardiosis, blastomycosis;
5. Botulism.

To destroy animals, U.S. specialists selected the following pathogens: hoof-and-mouth disease, large-horn cattle plague, pig plague, African swine plague, malignant anthrax, glanders, brucellosis, etc. To destroy agricultural plants, they may use agents of wheat rust, rice [pyriculariosis], potato phytophthora, and other diseases.

The destructive force of biological weapons depends on a series of factors: the biological properties of the pathogens, the living conditions of the people, immunity of the population (resistance to infection), level of sanitary conditions of the population, state of preventive medical treatment and antiepidemic decontamination facilities, the season, and other factors. The characteristics of the pathogenic microbes which may be used by the enemy are described in Appendix II.

If the enemy uses biological weapons to destroy the population, the following may result: inhalation of contaminated air; use of contaminated products and water; bites by infected insects and mites; invasion of mucous membranes and injured skin by microbes and toxins; contact with contaminated objects; personal contact with infected people and animals. With contamination by biological means, sickness does not appear at once; there is almost always a latency (incubation) period during which the disease is asymptomatic and the infected person is not disabled. The duration of the incubation period depends on the agent, the microbial invasion of the organism, and the general physical condition of the host. The latency period may last from 1 day up to 2 to 3 weeks.

Some pathogens (plague, cholera, smallpox) can be transmitted from infected to healthy individuals and by spreading rapidly can cause epidemics. It is very difficult to prove that biological weapons are being used and to identify the pathogen. It is reported in the U.S. press that no instruments currently exist with which it would be possible to determine when use of biological weapons was initiated. Thus, the basic method for determining the type of agent is analysis of specimens in the laboratory, which requires a great deal of time, sometimes as much as a whole day. All this makes it difficult to take the appropriate measures in time to forestall an epidemic.

2.4.2 Methods for the Application of Biological Weapons

There are different ways and mechanisms to infect people by biological agents. The enemy might use biological weapons in different ways in any season or at any time of the day. One of the most probable methods might be to contaminate the layers of the atmosphere near the ground with aerosols in the form of liquid or dry bacterial (viral, fungal, toxic) formulations.

Judging from the following considerations, the aerosol method is considered the most important by U.S. specialists: With this method it is possible to contaminate large areas, measuring tens, hundreds, or thousands of [square] kilometers. In the absence of protective measures, the aerosol method makes it possible to infect everyone in the zone of application. In this case, due to a large dose of pathogens invading the organism through the respiratory organs and the skin, it is possible for people to be infected even though they would ordinarily be immune. In addition, this method makes it possible to disperse agents of almost all infectious diseases, even those which are not transmitted through the air under ordinary conditions (for example, brucellosis, typhus, yellow fever, etc.).

It must be kept in mind that with the use of biological weapons contamination of people and farm animals and surrounding objects through the air can occur not only at the moment of biological attack, but for a long time afterward, for several hours and sometimes days. The possibility of such contamination is explained by the fact that the pathogens may retain their viability for a long time in the soil, on vegetation, and on the surface of various objects, and, in addition, [if] picked up by dust, they may create so-called secondary bacterial aerosols which are no less dangerous than the primary ones.

Biological pathogens can be disseminated among the human population and animals not only by aerosols, but also by vectors: insects, mites, and rodents. These disease-carrying vectors of infectious diseases can be easily cultivated in large quantities; they are infected and continue to survive as carriers of pathogenic microbes for a long period of time, sustaining the pathogens in their organism and transmitting them to people or animals. The life span of infected pathogenic vectors varies from a few weeks (mosquitos, fleas, flies, lice) up to several years (mites). Some vectors, mites for example, can transmit disease vectors to their progeny. These factors guarantee creation of persistent areas of contamination; this is also facilitated by the biological characteristics of insects and mites, used in active attacks on people and animals, and rodents, which also contaminate food sources and surrounding objects. To apply these biological weapons, the enemy may use rockets (Fig. 27*a*), airborne bombs (Fig. 27*b*), artillery shells and mines (Fig. 27*c*), packets (bags, boxes, containers) thrown from airplanes (Fig. 27*d*), special equipment for spraying or vaporizing (Fig. 27*e*), and sabotage (Fig. 27*f*) – [thus] contaminating air, water, and places where people gather, contaminating animals, and disseminating infected insects and mites to contaminate the population and their food products.

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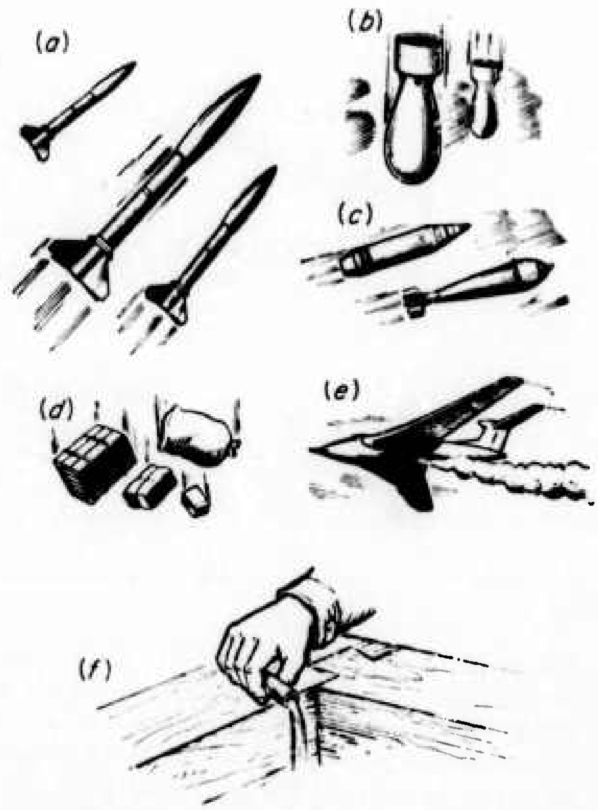

Fig. 27. Application of biological weapons.

2.4.3 Indications of the Use of Biological Weapons

Indications of the use of biological weapons are as follows: the appearance of streaks of smoke or fog in the wake of moving aircraft (Fig. 28*a*), a dull sound of the explosion of the microbe-carrying weapon (Fig. 28*b*), the presence on terrain of special aerial bombs, shell, and other containers (Fig. 28*c*), the appearance of drops of liquid or powdery substances on the soil or other objects (Fig. 28*d*), the appearance of hosts of insects, mites, or rodents – unusual for a given place or a given season (Fig. 28*e*), and the occurrence of epidemic diseases in people and animals.

Early detection of signs that the enemy has used biological weapons makes it possible in a short period of time to send qualified biological exploration teams to the contaminated region to determine the area of contamination and the nature of the pathogens, and thus to set up quarantines, if necessary, in time to control further attacks.

2.4.4 Focal Areas of Biological Contamination

A focal area of biological contamination is a territory exposed to the direct effect of biological media, creating the danger of spreading infectious diseases. Such a focal area may be produced by the use of pathogenic microbes which induce infectious diseases or of toxins injurious to human beings.

According to foreign specialists, the use of biological media is contemplated on targets deep in enemy territory: heavy industrial and administrative centers,

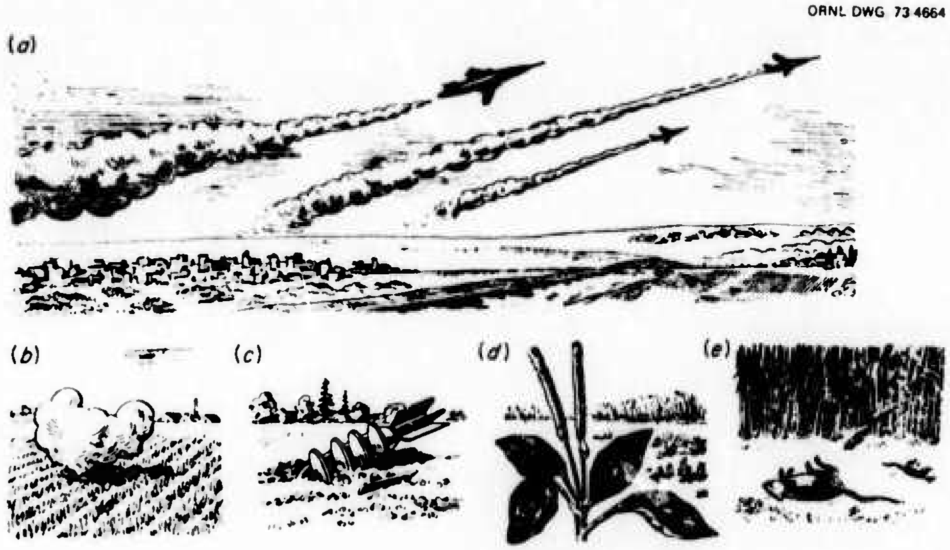

Fig. 28. Indications that biological weapons are being used.

railroad junctions, sea and river ports, and on large stores of agricultural products. The main danger of biological media used in war is the possibility of contaminating large territories. In their instructions in the use of chemical and biological weapons, the U.S. Army FM-3 (1962) points out that "with the use of one airplane or rocket it is possible to contaminate thousands of square kilometers in effective concentrations on enemy territory."

Biological media are used on targets in the rear areas to disrupt mobilization measures in the initial period of a war and to hamper deployment of armed forces by destroying troop contingents designated for movement to the front, as well as by destroying the urban and rural population subject to conscription into the army; to disorganize the rear of the country by creating a large number of contaminated areas and disrupting the normal operation of industrial plants and other national economic sites; to reduce the war-economy potential and create difficulties in the country by widespread transmission of infectious diseases; to infect food supplies and forage; to destroy agricultural animals and crops.

The size of the focal area of biological contamination depends on the type of munitions and the bacteriological formulations and their number and means of application, as well as meteorological conditions, how quickly the infections are detected, and on how promptly preventive treatment is given and decontamination measures are taken.

When bacterial formulations are released in the air, a bacterial cloud is formed consisting of minute particles of the formulation mixed with air. This cloud, moving irregularly with the wind, may settle on the ground, into water, onto plants, and on all objects, as well as on human and animal skin. If contamination occurs via the air and a large quantity of pathogens invade an organism, even inoculated people may be infected. Thus, a large number of people will require medical treatment in a hospital.

If biological media are applied by means of vectors, the size of the focal area of biological contamination is determined by the area where these disease carriers were dispersed. The special feature of this method of contamination is that insects and mites, as mentioned above, retain pathogens in their bodies from several weeks (fleas, mosquitos, and flies) to several years (mites).

Antiepidemic facilities of the CD medical service are organized on the periphery of the focal area of biological contamination, as determined by data from observation stations and reconnaissance teams and groups, as well as from meteorological and epidemiological public health stations. When a focal area of biological contamination is delineated by order of the CD chief of the area (republic, region), quarantine and observation are initiated.

3. Methods of Protecting the Population by Dispersal and Evacuation

3.1 ORGANIZATION AND PLANNING OF DISPERSAL AND EVACUATION

Should weapons of mass destruction be used, the enemy plans nuclear rocket attacks on the major cities and industrial and administrative centers that have defense importance. Industrial enterprises, transportation and communication centers, and other important objectives are usually concentrated in cities; at the same time, the cities contain large populations that work in these enterprises and that form the basis of productive capacity.

The fraction of the Soviet population living in cities is 55% (by 1967 data). Thus, the larger part of the population of our country lives in cities, many of which may become the targets of possible nuclear rocket attacks.

Under these conditions, civil defense takes on an especially important character, since its principal task is the defense of the population from weapons of mass destruction and the defense and conservation of the productive capacities of the state. V. I. Lenin once stressed: "The primary productive factor of all of humanity is the laboring man, the worker. If he survives, we can save everything and restore everything . . . but we shall perish if we are not able to save him" (V. I. Lenin, *Collected Works*, Vol. 38, p. 359).

During the Great Patriotic War [World War II], to remove productive capacity from areas of direct combat in our country, we transported entire enterprises, including their workers and employees, to the deep rear; that is, we evacuated industry. The evacuation of people, enterprises, and capital equipment was directed by the Soviet [Council] on Evacuation, which was organized by decision of the UCP(v) and by the Soviet of People's Commisssars of the 24th of June, 1941.

Under the direction of the government, all national departments and administrations organized special sections and commissions on evacuation. On-site the evacuations were supervised by Party and Soviet organs. A sequence of evacuation of enterprises, people, and capital assets was established.

The first enterprises to be evacuated were large ones with defense significance. (The evacuation included the workers, employees and their families, and the factory equipment.) From July through November 1941, over 1000 industrial enterprises moved into the interior of the country. Evacuation from the forward areas of the Don Basin, Stalingrad, and the northern Caucasus was conducted in the summer of 1942.

When evacuation took place, regions further than 1000 km from the front were inaccessible to the then current methods of attack. However, this evacuation was only partial in character, since a significant part of the population remained in the territory occupied by the German-fascist invaders.

Under conditions of a nuclear rocket war, civil defense must solve the problem of defending the population through a series of measures, which include dispersal and evacuation of people from cities that are likely to be targets of rocket attacks by the enemy. Evacuation should be made to areas outside the metropolitan areas, and the evacuees must be sheltered there in protective structures and also given individual means of protection.

The outer zone [see *] in this case means the territory between the external border of the area of possible destruction of the city and the border of the region [area, republic]. The boundaries of the zone of possible destruction must be established in relation to the importance of the city and the size of the population.

[*See drawing in footnote on page 4.]

3.2 THE CONCEPT OF DISPERSAL AND EVACUATION

Dispersal is the term used for an organized departure from the major cities and the distribution in the outer zone of workers and employees of national industrial enterprises that continue to function within these cities in wartime.

In addition to workers and employees of industrial enterprises, people who help operate the city should also be included in the category of those to be dispersed (for example, utility workers). These people must work within the city but return to the outer zone to rest.

Workers and employees of enterprises who are among those to be dispersed must, after relocation in the outer zone, go into the city in shifts for work at their enterprises and, upon completion of work, must return to the outer zone to rest.

Evacuation refers to the removal from a large city to the outer zone of that portion of the population which does not work in industrial enterprises within the city, and also the removal of the inhabitants of a zone of possible flooding into safe areas.

Some city enterprises should also be evacuated, including organizations, offices, and educational institutions whose activities during the war period can be transferred to agricultural areas.

Thus, those to be evacuated include the entire population not connected with enterprises that operate within the city in wartime, and also the staffs of administrative, scientific research, and educational institutions that would be evacuated for the duration of the war to the outer zone to continue their activities.

In the outer zone, the dispersed and evacuated population is located beyond the boundaries of the possible radius of destruction that would result from probable nuclear blows to the city, that is, at a safe distance from the city. This distance must be established in each specific case by the civil defense chief of the city.

The decision on where to locate the outer zone should take into account the distance that the essential workers would have to travel to and from the city each day. Round-trip travel time should not exceed 4 to 5 hr.

When the distribution of people in the dispersal areas is planned, it must be borne in mind that the dispersed workers and employees include not only the resting shift [off shift] of some enterprises, but also those civil defense formations responsible for rescue and repair operations at their enterprises. Thus, the dispersed workers and employees must be located no farther than 5 km from a railroad station or highway.

The evacuated population may be settled in areas that are farther from railroads and highways in their own regions and, in special cases, in areas of neighboring regions. [These regions roughly correspond to states.] (See Fig. 29.)

As a rule, dispersed workers and employees, as well as the evacuated population, would be billeted in the homes of the local population, whereas medical, trade, and other establishments would be distributed among tourist and sport facilities, schools, clubs, rest homes, sanitoriums, and nursing homes that are situated in the outer zone.

After completion of dispersal and evacuation, the only population left in the city would be the operating shift of workers, and employees of those enterprises that remain, and service personnel of the city. The rest of the city population is dispersed over a wide territory of agricultural lands.

These measures reduce the possibility of destruction of the dispersed workers and employees, as well as of the evacuated population, when nuclear attacks are made on the cities. Since only the operating shifts of enterprises must remain within the city, the problem of sheltering these people in shelters [blast shelters] at the enterprises, or very near them, is reduced. Under these circumstances, the requirements for shelters would be much lower than they would be if the entire city population were to be protected.

Calculations show that in case of a nuclear rocket attack the losses to the population in a large unprotected city may constitute 90% of the population, whereas in case of a timely and complete dispersal and evacuation of the population the losses may be reduced to several percent of the total population.

To make dispersal and evacuation measures effective and complete in the shortest possible time, such measures must be planned and prepared well ahead of time, while peace still exists. Under a socialist regime, the planned system of the national economy and the public ownership of land, houses, enterprises, and utilities provide favorable conditions for preparing evacuation regions to receive the city population.

3.2.1 Preparations for Dispersal and Evacuation

Preparations for dispersal and evacuation are made by the commanders of civil defense at all levels and their staffs. The dispersal of workers and employees and the evacuation of their families are conducted in accordance with industrial practices. For resettlement of workers, employees, and their families, the enterprises are assigned one or more adjacent populated points

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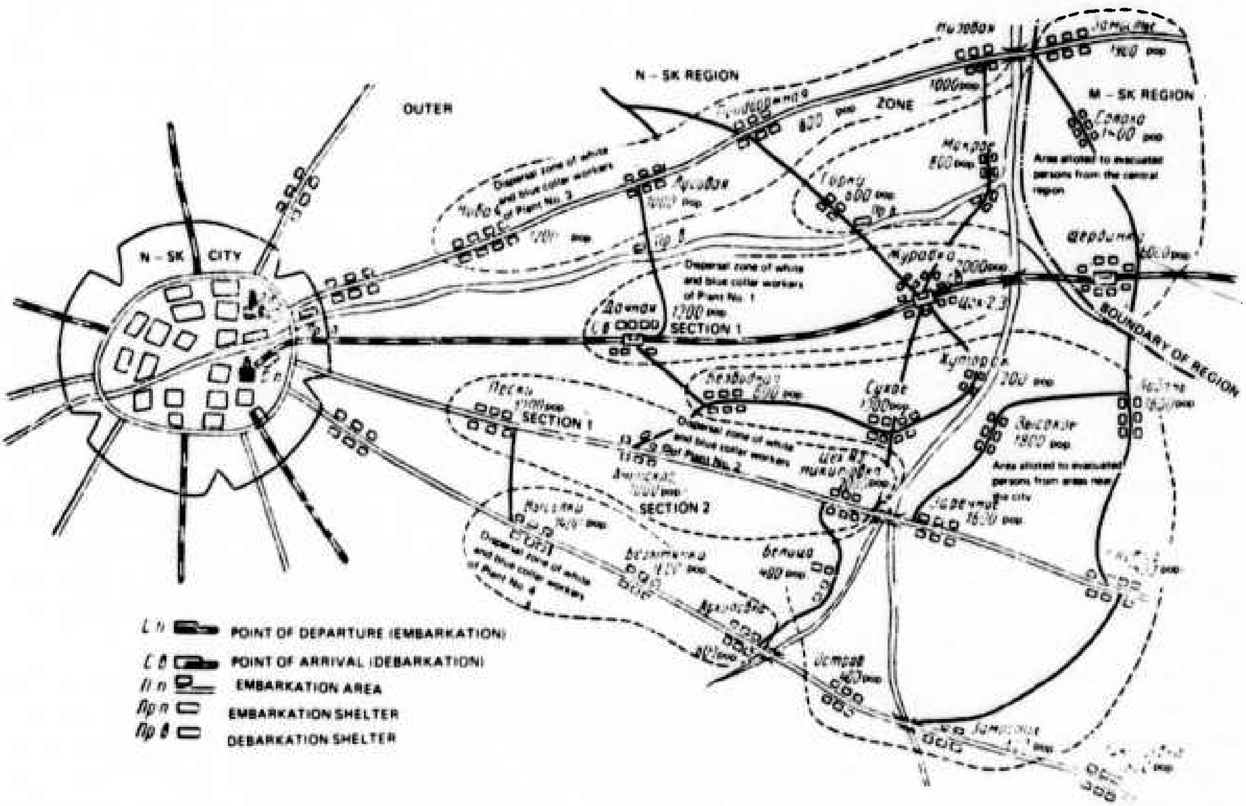

Fig. 29. Evacuation and dispersal areas.

(depending on the numbers of people to be resettled and the quantity of living space available). Under this principle the integrity of the enterprise is not disturbed: the workers and employees of one enterprise and the members of their families are resettled compactly, thus easing the tasks of collecting and transporting them for work in the city, of providing them with food and medical services, and of conducting Party-political work, mass-cultural work, and other measures in the areas of resettlement.

The population that is not connected with enterprises, offices, and educational institutions is evacuated on a territorial basis; that is, the population of each city district is resettled on the territory of one or two agricultural areas (depending on the numbers to be evacuated and the capacity of the agricultural area to absorb those resettled).

Preparations for and execution of dispersal and evacuation are the responsibility of the civil defense staff of each city or region or enterprise, and of special evacuation commissions organized in city and regional executive committees of Councils of Workers' Deputies, as well as at industrial enterprises, offices, educational institutions, and housing utilization offices (housing-unit management). Evacuation commissions are subject to the control of the Chief of Civil Defense and work in close cooperation with the civil defense staff. A city-district evacuation commission is created by decision of the respective executive committee of the Council of Workers' Deputies. The commission is composed of representatives from the Party and Soviet organizations, military headquarters, leading workers of planning organizations, trade organizations, health organizations, police organizations, educational organizations, social service organizations, and transport organizations.

The responsibilities of the city-district evacuation commission and of the civil defense staff of the city-district are: (1) registration of the population and of enterprises and organizations that are subject to dispersal and evacuation; (2) determination of regions for dispersal and evacuation and of their capacities for absorbing the population and offices and organizations; (3) the distribution in these regions of city districts, enterprises, offices, and other organizations; (4) a tabulation of means of transportation and its distribution over the various points from which dispersal and evacuation are to take place; (5) solution of the problems of material, technical, and other essential services for dispersal and evacuation; (6) the development, publication, and storage of evacuation documents and the supply of these documents to all evacuation organizations of the city; (7) the determination of time periods required for dispersal and evacuation.

In addition, the city evacuation commission conducts the selection and appointment of commanders of evacuation collection points and of evacuation commissions of city districts, and also prepares them for their work in dispersal and evacuation.

An evacuation commission is created at a given location upon the decision of the commander of civil defense of the location (for example, the director of the enterprise). The evacuation commission of the enterprise includes representatives of the Party committee, the management committee, the personnel committee, the staff and the civil defense staff of the enterprise, and heads of individual shops. The chairman of the evacuation commission of an enterprise is the deputy commander of the civil defense organization of the enterprise and deals with dispersal and evacuation. The basic work of the evacuation commission of the enterprise includes: (1) a tabulation of the number of workers, employees, and members of their families that will be dispersed and evacuated; (2) the preparation of areas for dispersal and evacuation and of the points of embarkation and debarkation of those evacuated; (3) organization of communications and interaction with the regional evacuation commission and the evacuation collection point.

The evacuation commission operates in cooperation with the civil defense staff of the enterprise.

Dispersal and evacuation are conducted through evacuation collection points that are created by the city-district evacuation commission.

The evacuation collection point is given a permanent number. These evacuation points are assigned the responsibility of alerting, collecting, registering, and preparing for departure the population that is to be dispersed and evacuated; organizing embarkation on various forms of transport and dispatching the transport to the outer regions; informing the population about the situation and the areas of distribution for those dispersed and evacuated; organizing shelter for the people at the evacuation collection point upon the signal "air alert"; notifying the evacuation commission of the numbers evacuated and dispersed to the outer zones within the time periods established.

The collection points for evacuation are organized in communal buildings (schools, clubs, etc.) near the point of embarkation designated for service to the collection points (near railroad stations or platforms, docks, parking areas for automobile transport). The locations for organizing evacuation collection points are fixed by the evacuation commission.

The staff of the evacuation collection point and the responsibilities of its members are listed in Appendices III and IIIA.

The commanders of the evacuation collection points are confirmed in their post by resolution of the city-district executive committees of the Councils of Workers' Deputies, upon recommendation by the chairman of the city-district evacuation committee. Such commanders must come from the management staff of enterprises, offices, and organizations from which evacuees will come to the respective collection points. Assistant commanders of the collection points are also chosen from the administrative staff, while the rest of the staff consists of workers and employees of those enterprises, offices, and organizations for which the collection points are intended.

The commander of the collection point organizes a file with working documents, which is kept at the enterprise, at the bureau, or at the Housing Utilization Office. In this file are placed instructions to the staff of the evacuation collection point, calculations prepared for the staff, a diagram of the collection point with a list of instructions on the distribution of all its elements, a listing of people subject to dispersal and evacuation, a diagram and data for their instructions, blanks for certifications of evacuation, graphs to show the times for start-up of transports of embarkation and the times for their departure, route listings for the commanders of automobile convoys or of railroad assemblies, tickets for embarkation, and other documents.

A definite number of people are assigned to each evacuation point, and places are assigned for dispersal of this population to the outer regions. Means of transportation are assigned, and the points of embarkation and debarkation and the routes for the means of transport from the assembly point to the reception point are designated.

As a rule, the operation of the evacuation collection point is planned so that the evacuees leave in only one type of transport: motor vehicle, train, or boat. The population that is to be dispersed and evacuated must be notified early enough concerning who goes where and when during the evacuation (after the government gives the order for dispersal and evacuation), what things and documents are to be taken, and in what order evacuation documents should be presented.

The times for people to come to the collection points are determined from the transport plan and their [projected] arrival at the embarkation point.

In agricultural regions the measures taken for reception and distribution of the evacuees are the responsibility of the commanders and staff of civil defense of the agricultural region and of collective and state farms. Commissions must be created to deal with the reception and distribution of the dispersed workers and employees and of the evacuated population. These commissions are created within the executive committees of the Council of Workers' Deputies of the agricultural region. Composition of the commissions must include representatives of the regional committee of the Communist Party of the Soviet Union, of the military command, of the staff and the operating civil defense personnel of the area, and of the collective and the State farms. The head of the commission is the assistant chairman of the regional executive committee.

The commissions prepare for the reception and distribution of those evacuated, as well as the organization of food supplies, living essentials, and medical and other services and supplies.

For the reception of the evacuees, the regional commission must organize evacuation reception points.

Composition of the evacuation reception points and the functional responsibilities are listed in Appendices IV and IVA.

The staff of an evacuation reception point is made up of representatives of Party and Soviet organizations. Evacuation reception points must be located near stations, docks, and other places where debarkation occurs. Representatives are selected by the regional commission, and the evacuees are distributed in accordance with the directives of the executive committee of the Council of Workers' Deputies of the region.

3.2.2 Planning the Dispersal and Evacuation

An actual dispersal of workers and employees and evacuation of the population to outer areas are effected upon the decision of the government of the USSR. Some basic data used to plan dispersal and evacuation of a city population are:

1. the total population living in the city; the number of enterprises, offices, educational institutions, scientific research institutes, and other organizations and enterprises; the number of workers and employees to be dispersed, together with the members of their families; the number of persons who are to be evacuated;
2. the number of settlements in the agricultural area and the number of buildings there that are suitable for sheltering people, offices, and enterprises; the medical service situation in the settlements;
3. the availability of railroad, automobile, and marine transportation and their throughput capacity; the number of railroad stations and platforms, docks and landing areas, and points of embarkation and debarkation; the condition of bridges; the possibility for increasing the capacities of roads and water transport ways;
4. the availability in the city and in the outer zones of medical facilities and personnel, medicines, and preventive medicines; the availability of medical treatment for the population at the collection points, over the evacuation route, and in the regions where dispersed people and evacuees are to be distributed;
5. availability of water supplies and their characteristics and the possibilities for creation of new water supplies;
6. availability and location of food stores; quantity and capacity of enterprises for feeding the community; availability of bakeries and bread factories and their production capacities; the possibility of organizing mobile feeding stations and methods for obtaining additional required foods;
7. availability of radioactive fallout shelters, their capacities, and shelter characteristics; availability of local construction materials for erection of radiation shelters; availability of individual shelters;
8. meteorological conditions characteristic of the area, the average prevailing winds; the possibilities of catastrophic flooding.

Of all the essential data listed, the most complicated is a listing of the people who are to be dispersed and evacuated. This work must be accomplished early enough, by the personnel departments of enterprises, housing administrations, and the passport desks of the police.

Having studied and evaluated the basic data, the city-district civil defense staff and the city-district evacuation commission develop plans for evacuation and dispersal, which are then approved by the commander of civil defense of the entire city or region. The plans must provide for the distribution of the city districts and the enterprises among the outer regions, the necessary number of evacuation collection points and the locations for them, the locations of the means of transportation for the evacuation, the organization of material, and technical and other necessary measures.

To the plan are attached the following: a text of the announcement about dispersal and evacuation; a map showing the dispersal and evacuation; instructions to the commanders of the evacuation collection points, the railroad train assembly, and the auto convoy.

The dispersal and evacuation map must indicate: the name of the enterprise, office, or organization; the numbers of the evacuation collection points; the transport that is assigned to them; the locations for embarkation and debarkation; the distribution points for those to be dispersed and evacuated to the outer zones; the time periods allotted for dispersal and evacuation; and those people responsible for the evacuation and dispersal.

The civil defense organizations (transport, militia, medical, food supplies, materiel, etc.), in cooperation with the civil defense staffs of the city or region, develop their own plans for dispersal and evacuation, which are appended to the general plan.

Extracts from the city or regional plan for dispersal and evacuation are delivered to the industrial enterprises and are limited to those passages that are pertinent to them.

Based on data of the city or regional plan, the civil defense staff of an enterprise and the evacuation commission work to prepare and execute the evacuation and dispersal.

Among the responsibilities of any given civil defense staff and of any given evacuation commission are the following: studies of the region for dispersal and evacuation, the routes for evacuation, the points of embarkation and debarkation; the organization of communications with the evacuation collection point, a listing of workers, employees, and members of their families who are to be evacuated and dispersed; a listing of the kinds of transport available; organization of the materials and other kinds of supplies. In addition, the civil defense staff and the evacuation commission of the location establish contact with the reception point of the evacuation commission of the agricultural region and confirm with it the number of settlements and the amount of living space that is available and suitable for distributing the evacuees; the order for reception and distribution of workers and employees of an enterprise and members of their families; possibilities for employment of the evacuated; food supplies; the food distribution network and the trade network; organization of the materiel and other forms of service; the availability of local transportation, etc.

When planning the distribution of the evacuees among the settlements, it is essential to avoid overcrowding. Approximate standards of distribution may be as follows: for each local inhabitant, there may be one to two evacuated people, or two to three square meters of living space for each person (that is, both local and evacuated).

Summaries of the preparatory work of the civil defense staff and the evacuation commission of the location are studied by the civil defense commander. He examines the proposals of the staff and makes decisions; based on these decisions, the civil defense staffs of the location form their plan for distribution and evacuation (see Chapter 7).

3.2.3 Supplying the Requisites for Evacuation and Dispersal

Supplying transport. Transportation for evacuation and dispersal applies to the movement of organizations, their workers, employees, and members of their families to the dispersal areas; transportation of the population to the evacuation region; transportation by shifts of workers and employees from dispersal regions to the city, to the enterprises for work, and back to the dispersal area for rest.

Transportation of dispersed workers, employees, and evacuees is effected by railroad, water, and automotive transport. The principal means are railroad and automotive transport.

The capacities of railroads for evacuation are determined by the command staff (sections) of the railroads, with the participation of representatives of the civil defense staff of the city or region. Together they develop various means for providing transportation, depending on the capacity of each section or tract, the number of people to be dispersed and evacuated, the numbers and times for transportation or working shifts to the enterprises (those that do not interrupt production in wartime), places for embarkation and debarkation, the capacities of the areas of distribution, and other conditions.

The management (departments) of the railroads makes up graphs of the transport movements and informs the city or regional civil defense staff of the number of trains (assemblies), the number of people that may be transported in each of them, stations (points) of embarkation and debarkation, and the times of departures. Requisite to calculating the departure times for trains during an evacuation is the reliable notification of the onset of dispersal and evacuation.

Information on these matters, as well as data on the capacities of other forms of transport, enables the urban civil defense staff to plan transportation of the population by various means.

During preparation for evacuation transport, sequences are developed for embarking and debarking people under conditions when cars must be loaded to maximum capacity and [for giving] the rules of conduct for the evacuees when embarking, when enroute, and when debarking. These are developed in cooperation with the managing staffs and commanders of railroad train assemblies.

Automotive transport is planned and organized by the commander of the motor pool of the city's civil defense organization, in accordance with notifications from the civil defense staffs of the various enterprises.

The commander of the motor pool determines the problems involved in providing transportation for evacuation and dispersal and makes them known to those responsible for executing the transport operations. These communications must indicate:

1. to whom, where, in what quantity, and under whose command the means of transportation may be released, the location and the purpose of the transports;
2. the sequence of steps and the time allocated for equipping the means of transportation for movement of people;
3. the routing of the transportation and the schedules for the trips;
4. the supply of fuel for automobiles and trucks and the supply of lubricants and spare parts;
5. places and sequences for maintenance operations for auto transport.

To ensure a centralized direction of the automotive transport and precise operation of the motor pools, a city must organize auto convoys, consisting of 20 to 30 automobiles. Commanders of the convoys are designated and dispatcher points organized. Automotive convoys are assigned specific routes and specific evacuation collection points so that each convoy operates, as a rule, over only one route.

Buses are also assigned to transport people, as are light and heavy trucks and specially equipped dump trucks.

After the directive (order) for dispersal and evacuation, an automotive convoy must report to the evacuation collection points at the designated time and, depending on the capacity of the embarkation point, go to the actual embarkation location either in one column or in groups of five to six vehicles.

When calculating automotive transport, it is essential to know the passenger capacity of the vehicles. Trucks and dump trucks must be equipped with seats for transporting people.

Representatives of the enterprise, offices, and organizations that are being evacuated must accompany the convoy from the evacuation collection point to the various distribution areas in the outer regions.

During the distribution of workers and employees of an enterprise, a commander of a shift that is being transported can designate one of his assistants to be in charge of the operation. This person is [then] responsible for the organization and rapid departure of a shift that has been resting, for its transportation to an outlying region, and for arranging for the nourishment and rest of the workers and employees, as well as for the timely delivery of the rested shift back to its place of work.

The continued smooth operation of the enterprise will depend to a large extent on the efficient and precise operation of the transportation.

Roads. Road service includes the organization and execution of measures to ensure uninterrupted transport along the automobile highways during an evacuation.

Automobile highways are subdivided into operating sections 150 to 200 km long.

To ensure uninterrupted transport during the period of evacuation, automobile highways must be equipped with repair points (based as far as possible on existing automotive enterprises) and stationary and portable fuel supplies. In addition, at places specified by the civil defense plan, stations and areas for decontamination of transport and points for medical processing must be established.

Among the primary responsibilities of the commander are: maintenance of the road and the structures along it; distribution of necessary signs and indicators; organization of emergency technical services; organization of guards and protection of the most important locations along the road; and also assistance to the police service in directing traffic and safety.

To maintain order at distribution and evacuation points, civil defense police functions are organized. Their responsibilities include traffic control and public safety along the evacuation routes, the implementation of specified measures, control over orderly traffic movement, and protection of the most important equipment along the road and of industrial enterprises.

For each section of the route a commandant is appointed. Tractors and other road equipment are allocated to him, particularly in areas that are difficult to cross.

Command posts are designated and outfitted, and check points are organized and staffed by personnel of public safety organizations, with the necessary means for transportation, communication, and chemical and radiation monitoring.

The command function is organized by the civil defense staff of the city or region. Direct control of this function is given to the commander of the public safety organizations of the city or region by the commanders of the routes (regions and crossing points) and the commanders of the command posts (the check points).

Measures for organization of the command function are reflected in the early development of plans by the staff. These plans indicate:

1. the purpose and the principal goals of the command staff, its strength, and the resources at its disposal;
2. the locations of command posts and traffic control posts; their composition; their equipment for transport, traffic control, and communications;
3. the composition and location of personnel and equipment of the command staff,
4. organization of communication and control;
5. areas and routes (sections of routes) over which the command staff is assigned authority by the headquarters staff.

Before the convoys of dispersed and evacuated people depart, the command staff is distributed over the routes that these convoys will take.

Material. Material requirements consist, first of all, of food and other essentials, together with their supply and distribution to the evacuated population.

The organization of supplies for the dispersed workers and employees and for their evacuated families is the responsibility of the deputy chief of civil defense for materials and technical supplies.

In cooperation with civil defense agencies of the city-district and of the agricultural region, he makes preparations for supplying, in the outer regions, the workers and employees of an enterprise and the members of their families, and also organizes the feeding of working shifts.

The supply of food to the evacuated population and of essentials to the outer zones is organized through local trading organizations, through the network of communal food supplies, and through community services. City trade enterprises and community service enterprises are transported to the outer areas simultaneously with the dispersal of workers and employees and the evacuation of the population, and are used to increase the capacity of the established network of supply in the outer evacuation region.

Enterprises, clinics, children's organizations, and educational institutions take with them into the outer zones their own supplies of food and means for organized feeding and supply through their own dining rooms and ORS [?]. The enterprises and organizations that do not have their own mess facilities, and all the rest of the population, are assigned for feeding to mess facilities at the points of distribution, or they obtain food through the trading network of the agricultural regions.

The feeding of working shifts of enterprises is organized through already existing or newly formed mess facilities. Food is supplied to dining rooms at locations by the food services and by the supply services of the city, or the city-district gathers, for this purpose, stores of foodstuffs within the limits of established standards.

The supply of drinking water in the outer zones is obtained mostly from artesian, drilled, or piped wells, and from other enclosed water supplies.

Medical service. Responsibilities of the medical service for dispersed workers and employees and the evacuated population include: medical aid for the sick and injured, their medical care in medical establishments; the timely execution of antiepidemic measures to prevent infectious epidemics; control of sanitary conditions at points of embarkation, debarkation, and eating stations, as well as in areas of temporary habitation and in areas where evacuated people are more permanently distributed.

Medical aid to dispersed workers and employees and to the evacuated population is conducted at collection points, embarkation points, stops, and points of debarkation and distribution, as well as at the enterprises themselves.

During a period of dispersal of workers and employees and the evacuation of the population, local or administrative enterprises make available, at the collection and embarkation points, medical personnel and organized medical care centers. The personnel of these centers is evacuated with the last convoy, that is, at the conclusion of the work of collection at the evacuation point.

At the places where the dispersed workers and employees and the evacuated population are distributed, medical care is organized by the medical services of the agricultural regions with the help of the personnel of the evacuated medical enterprises and of the medical organizations of industrial enterprises, and also of the local clinical and preventive-medicine organizations.

Part of the medical personnel is assigned to the staff of the mobile civil defense formations to give medical aid to members of the population who may have suffered in nuclear attacks on cities.

Supplies, as well as workers and employees of operating shifts, are organized at medical enterprises by the commander of medical services of the enterprise. Medical service is rendered through sanitation posts and nursing aid centers, which are set up well ahead of time for each shift. Medical attention by a doctor is administered through the clinical centers and through mobile clinics. Specialized medical aid and treatment in fixed locations are conducted in hospitals of the outer regions, while first aid to nonmobile sick is rendered in city hospitals. When infectious illness appears, suspected victims and those who have been in contact with them must immediately be isolated and evacuated by special transport to the nearest infectious illness hospital, with the implementation of strong measures for epidemic control.

In addition, during the period for sheltering the workers and employees, the medical groups and the personnel of sanitation posts (that operate on a shift basis) are uniformly distributed for first aid services among the defensive facilities.

3.2.4 Radiation and Chemical Defense

Radiation and chemical defense, under conditions of dispersal of workers and employees and evacuation of the population, consists of organizing radiation and chemical monitoring, of supplying individual and collective means of defense, and of providing health physics services.

Radiation and chemical defense of workers, employees, and the members of their families is organized and conducted both on-site in the city and in the dispersal and evacuation zones.

To accomplish this, the civil defense staff of the enterprise organizes radiation, chemical, and meteorological monitoring at the collection and reception points for evacuation, along the evacuation route, and at the evacuation sites in the outlying zone.

At the sites of the evacuation collection points, shielding shelters must be prepared in advance so that those being dispersed and evacuated can take shelter in case of an "air alert" signal. In the outlying zones, at the evacuation receiving stations, and in the areas where evacuees are quartered, on-site facilities (cellars, vegetable storage bins, etc.) that can also shelter the population must be prepared in advance.

When the dispersal and evacuation are announced, the civil defense staff begins to supervise the preparation of shelters at the enterprises and, in the areas of the evacuation collection points, the preparation of individual civil defense equipment and other antiradiation measures; it also checks on the state of readiness of shelters in the outlying area at the resettlement locations for workers, employees, and their families; organizes the preparation of the most simple means of individual protection and the construction of radiation shelters in the outlying zone, using for this purpose cellars, basements, mine shafts, mining diggings, and various structures that are below ground level.

At resettlement sites of workers and employees in the outlying zones, a continuous monitoring of the radiation situation is organized; also, a warning system is developed, as is a set of rules for the population to follow in case of radioactive contamination. In addition, there is organized study of civil defense signals and the actions to be taken under specific real conditions.

If a center of contamination does develop, the civil defense staff announces the measures and actions to be followed by workers and employees, depending on the situation.

3.2.5 Putting Dispersal and Evacuation into Effect

Sequence of announcements. Among the measures required for dispersal and evacuation, the means for informing the population are very important.

Dispersal and evacuation are initiated upon orders from the government. The various civil defense staffs receive such orders in a predetermined manner and then transmit them to the managements of enterprises, offices, and other organizations by means of radio broadcasts, television broadcasts, telephone, and messengers. The general population is notified through local radio broadcasts, as well as through enterprises, offices, educational institutions, rental offices, building superintendents' offices, and police establishments.

In the daytime, when radio relay stations are usually operating, as well as radio and television sets, the population can be notified quickly of orders for evacuation and dispersal. At night, when these devices are usually turned off, spreading the word becomes more complicated. If the situation demands immediate notification at night, then special automobiles equipped with public address systems may be sent into all regions of the city to waken the residents and transmit the orders to them. Telephone and street loudspeaker systems may also be used for this purpose, as well as the instructors of the evacuation collection points and the workers on night shifts at various enterprises.

Assembly and departure of evacuees and dispersed persons. After notification of the onset of dispersal and evacuation, the evacuation collection points start to operate at once and to assemble and route those being dispersed and evacuated.

Workers and employees must arrive at their collection points at the times designated for them. As a rule, the workers and employees to be dispersed are relocated in the outlying zone, together with their families. Thus, they all arrive together at the collection points.

If it is impossible to evacuate families as units, the dependents are moved to more distant regions; therefore, their times of arrival at the collection points may differ from those of the workers and employees.

Those who are dispersed and evacuated must take with them documents, money, and necessary items and food for two to three days. At the evacuation collection point the people are registered and obtain tickets for embarkation. On this ticket, the number of the convoy or train and the time and location for embarkation are indicated.

After registration and ticketing, the people are grouped according to their assigned railroad car or motor vehicle, under the direction of a deputy commander of the evacuation collection point and the commander of the train or convoy. At the appointed time these groups move out to the embarkation points.

The actual embarkation is supervised by the senior people of the railroad car or motor vehicle [truck, bus, or car]. Once embarked, the evacuees are not allowed to leave the railroad cars or motor vehicles without permission of the supervisors.

After arrival at the evacuation destination, debarkation takes place on order of the train or convoy commander, and the people then go to the evacuation reception point, where once more they are registered and assigned to settlements, to which they proceed in an organized manner.

In the cases of children, invalids, and the very old, their possessions must be moved by local transport. The places for distributing these people and their possessions are farther than 5 km from the evacuation collection point. The evacuees must be carried by the local transportation of the collective farms and state farms.

Party-political work during evacuation and dispersal. The successful execution of evacuation and dispersal depends to a significant extent on the morale and the political state of mind of the evacuees, and also on the level of Party-political work.

Party-political work is based on the Program and Directives of the CPSU (Communist Party of the Soviet Union), on the decision of the TsK CPSU (Central Committee of the Communist Party of the Soviet Union) and of the Soviet Government; on the orders and directives of the Military High Command and of the Commander of Civil Defense of the USSR; on the decisions, directives, and instructions of the TsK of the Communist Parties of the Union Republics, Regional Committees, District Committees, City Committees, and Borough Committees of the CPSU.

The specific contents of the Party-political work and the ways and means of its implementation under various conditions and situations are determined by the nature of the problem and by local conditions.

Party-political work is organized by city and borough committees of the CPSU, while at the sites themselves it is organized by the Party organizations of the enterprises, offices, and educational institutions.

Under the direction of Party organs, even in peacetime, propaganda must be conducted — knowledge of civil defense must be spread by means of both visual aids and oral addresses, the press, radio, TV, and movies. All of these means must propagate knowledge about ways to defend the population from weapons of mass destruction.

The purpose of the propaganda is to explain the measures and methods used to provide protection from weapons of mass destruction, to popularize civil defense and its problems, to make the entire population knowledgeably aware of the importance of civil defense measures under modern conditions, and to prepare the people psychologically and strengthen their morale for the difficulties and grim experiences that may occur if the imperialists unleash a war.

The rapid course of events that will be a characteristic of a nuclear rocket war will require a very fast reaction to events from both the civil defense forces and the entire population. One of the conditions for reducing losses among the population would be the early and smooth execution of dispersal and evacuation; thus, one of the most important problems is that of making clear to workers, employees, and the population all the measures that must be implemented for dispersal and evacuation, and the role and the place of each person in the execution of these measures.

In the period of threat of enemy attack, the Party committees of each enterprise must distribute Party-Komsomol [young Communist League] and trade-union activists among the evacuation collection points, trains, and convoys. The committees must provide these activists with all information; they must understand the importance of counteracting panic; they must inform those being evacuated of the rules of conduct at embarkation, in transit, and upon arrival. The Party committees must organize propaganda brigades for work in the resettlement areas, among those who are evacuated and dispersed; they must also organize lectures and discussions, show movies, give radio broadcasts, make bulletin boards, issue war communiques, and make propaganda posters.

Primary attention must be directed to explaining to the population the details and particulars of the actual situation, to fostering faith in the righteousness of our cause and in the certainty of victory over the enemy.

The problem of work placement at the evacuation locations has considerable significance, both economic and political. Thus, placing evacuees in jobs is one of the concerns of Party-political work.

4. Individual Means of Protection

4.1 DEVICES FOR PROTECTING THE RESPIRATORY SYSTEM

The individual means of protection include gas masks and devices for protecting the skin against toxic and radioactive, as well as biologically dangerous, materials.

The most important protective device is the gas mask. It is intended to protect the respiratory system, the face, and the eyes from the effects of toxic materials in any form (vapor, fog, gas, smoke, droplets), radioactive substances in the form of airborne radioactive dusts, and pathogenic microbes and toxins introduced into the air in the form of fogs (aerosols).

4.1.1 Basic Gas Mask Design

Gas masks can be classified, according to the type of protection they give, into two categories: filter and air-supplied types. In the filter-type gas masks, ambient air is purified before respiration by removing the majority of foreign materials that are harmful to man. In the air-supplied gas masks, completely self-contained respiration is made possible by providing oxygen in the apparatus itself and by purifying exhaled air to remove gaseous carbon dioxide and moisture.

Air-supplied gas masks (apparatus) have multiple protective characteristics, that is, they protect from all toxic materials, radioactive dust, and biological aerosols in any concentration. However, their essential disadvantages, besides being heavy and cumbersome, are their short service life and the comparative complexity of their design and use.

Thus, the filter-type gas mask has received the most widespread popularity and is the basic means for protecting the respiratory system. Before we begin to familiarize ourselves with models of protective devices for the respiratory system, let us briefly examine the principles on which these devices operate.

The removal of vapors and gases in the cartridges of filter-type gas masks occurs as a result of adsorption, chemisorption, and catalysis. Air is purified by the removal of radioactive dust, biological media, and toxic materials in the form of fog and smoke by filtration.

Adsorption is the retention of molecules of any substance on the surface of a solid due to forces of intermolecular attraction. A solid adsorbing any substance on its surface is called the adsorbent. The amount of substance adsorbed depends on the nature of the surface on which adsorption takes place. The more porous the adsorbent, the more readily the adsorption process takes place, and the greater the amount of adsorbate.

Carbon is the most suitable adsorbent in gas masks; it is highly porous and consequently has a large surface. But ordinary carbon does not have sufficient adsorptive power for toxic materials because most of its pores are filled with resinous materials, carbon dust, and combustion products. To increase the adsorptive power of carbon, it is subjected to a special activation treatment.

The activated carbon, in the form of small pellets or granules, is the basic component of a gas mask adsorbent. In contrast to untreated carbon, activated carbon has an enormous free surface; for example, 1 g of activated carbon has a free surface of about 800 m^2. Activated carbon adsorbs toxic materials of the sarin and yperite (mustard gas) type, etc., very well.

However, not all toxic materials can be trapped on the surface of activated carbon by the forces of intermolecular attraction alone; some gaseous toxins, for example, prussic acid, are capable of penetrating a layer of activated carbon and are not trapped by its pores. Purifying the air by removing such toxins is accomplished by chemisorption, that is, chemical conversion of toxic materials into nontoxic neutral substances. To this end, chemicals are added to the gas mask adsorbent. Toxic materials entering the gas mask react with these chemicals and are converted into innocuous materials.

The process of chemical interaction between the gases and the adsorbent usually takes place slowly, but in the gas filter cartridge it must take place in hundredths of a second because the rate of air flow through the adsorbent with inhalation is high, that is, about 1 m/sec. Therefore catalysts, that is, special chemical accelerators, are used to speed up the chemical reactions occurring in the gas mask. Thus, catalysts which accelerate the reactions of chemical adsorbents with toxic materials are a necessary part of the protective features of the gas filter cartridge.

In modern filter-type gas masks, this addition is achieved by a very thin layer of activated carbon which has the power to adsorb any known toxic material. The properties of the adsorbent may change depending on the composition of the catalyst, in particular, its adsorptive power for different toxic materials.

The process of adsorbing any toxic material on the surface of an adsorbent particle cannot go on indefinitely. After saturation of the adsorbent particle with toxins, which may occur at any moment, adsorption stops. However, gas mask protection does not stop because the time when the individual adsorbent particles will become saturated by toxins has been determined, as has the duration for which the entire gas adsorbent will guarantee protection from toxic materials, that is, the time at which the entire gas adsorbent layer will become saturated and the so-called breakthrough of toxic materials will take place. When the breakthrough occurs, the gas filter cartridge must be replaced [see footnote *].

Another process occurring in the gas filter cartridge is filtration, which protects the respiratory system from radioactive dust, toxic fumes and vapors, and biological media. Radioactive dust, biological aerosols, and toxic smokes and fumes consist of particles which, according to their size and quantity, may [*not*] be trapped on the surface of the adsorbent only by intermolecular forces. Thus, for protection against these materials an aerosol or so-called smoke filter is used in the gas mask.

Filtering cardboard is used in modern gas masks as a smoke filter which is comparatively dense, consisting of a large number of fine fibers and filaments and filtering material made of synthetic fibers; almost all particles of radioactive dust, biological aerosols, and TM smoke or fog entering with air through the smoke filter settle on its surface (are filtered) and are retained there by forces of intermolecular attraction.

[*Obviously, a gas filter cartridge should be replaced *before* breakthrough occurs.]

To evaluate the filter materials in a gas filter cartridge (with regard to filter efficiency), breakthrough factors are used; these are expressed in percent:

$$K = \frac{C_1}{C_0} 100 ,$$

where C_1 is the concentration of aerosols after flow through the gas filter cartridge and C_0 is the concentration of aerosols before flow through the gas filter cartridge. It follows from this that the lower the breakthrough factor, the greater the protective properties of the adsorbent.

In gas filter cartridges, the smoke filter and the activated carbon (packing) are situated so that inspired air flows first through the smoke filter and then through the packing. This arrangement results in the following: The toxic smoke particles trapped by the smoke filter may evaporate, and these vapors will be adsorbed on the layers of the packing; when the smoke filter is placed behind the packing, these vapors would not be adsorbed and would invade the human organism and cause injury.

There are presently several filter-type as well as air-supplied gas masks.

4.1.2 Filter-Type Gas Masks

Functional principles of the gas mask. The basic filter-type gas masks intended for general use are designated GP-4Y (Fig. 30*a*), GP-5 (Fig. 30*b*), DP-6, DP-6M (Fig. 30*c*, *d*), and the child's protective chamber, KSD-1 (Fig. 30*e*).

The GP-4Y (Fig. 30*a*) is designed for the adult population. It consists of a gas filter cartridge (1) and face mask (2); the gas mask is carried in the gas mask bag.

The gas filter cartridge GP-4Y (Fig. 31) purifies inspired air by removing toxic and radioactive substances and biological media; it is made of tin and is cylindrical. To increase the mechanical stability of the housing (1), transverse external corrugations (ridges) are embossed. On the upper part of the cartridge there is a cover (2) with threaded neck (3) for attaching the connecting hose; in the lower part, there is a base (11) with aperture (12) for the entry of inspired air.

Inside the cartridge there are two perforated (screen) cylinders, situated one inside the other. The upper part of the small screen cylinder (5) is fastened to the cartridge neck, and the lower part is closed with a metal cap (13). Next to the small cylinder, there is a large

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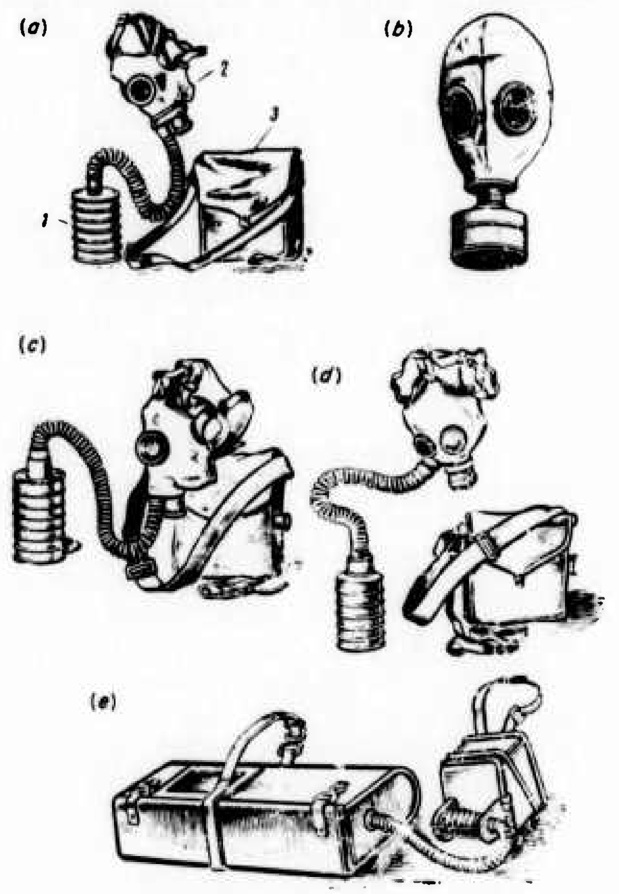

Fig. 30. Gas masks for the civilian population.

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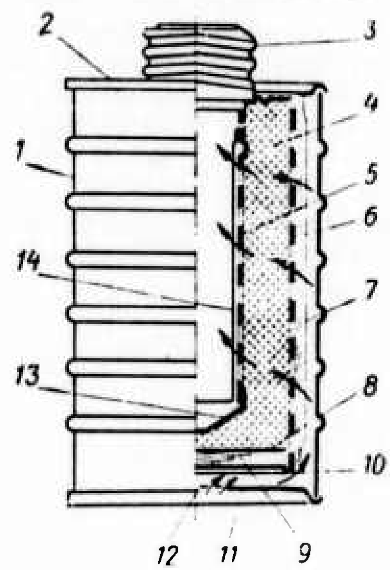

Fig. 31. Cross section of the GP-4Y gas filter cartridge.

screen cylinder (6) which is fastened by its upper part to the roof of the cartridge, while in the lower part there is a fixed bottom (10).

The space between the large and the small cylinders is filled with packing (4) (activated carbon with a chemical additive), which is contained by a movable bottom (8) below. The movable bottom is supported by a spring (9).

A folded, corrugated smoke filter (7) is fastened to the outer surface of the large screen cylinder and traps smoke, fog, radioactive dust, and biological aerosols.

A dust filter (14) of long-fiber paper is fastened to the inner surface of the small screen cylinder. The dust filter is designed to trap dust formed in the gas mask as a result of friction between packing particles.

When outside air is inspired through the aperture in the bottom of the gas filter cartridge, it enters the space between the cartridge housing and the smoke filter where it is cleansed of toxic particles, radioactive dust, and biological aerosols. Further on, the air flows through the packing layer, where it is cleansed of TM gas and vapors, passes on through the dust filter, arrives purified at the connecting hose under the face mask, and enters the respiratory system.

The face mask feeds the purified air into the respiratory organs and protects the eyes and face from TM, radioactive materials, and biological media. It consists of a rubber mask with protective goggles, straps, a valve box, and a connecting hose. The eye pieces are made of glass and are snapped into the body of the mask by serrated rings. The rubber head band and the straps hold the mask on the head and keep it tight against the face; the tightness of the straps is adjusted with buckles. The masks are made in three sizes: 1, 2, and 3. The size is indicated on the mask chin with the numbers 1, 2, 3.

The valve box (Fig. 32) is made of tin and distributes and directs the stream of inspired and expired air. It is fastened to the body of the mask (to its lower part) with small wires and rubberized tape. The valve box contains one air inlet and two air outlet valves.

The air inlet valve head (1) is a rubber disk with an aperture in the center through which the stem passes. When air is inhaled, the valve head rises and admits air into connecting hose (4) under the mask; when air is exhaled, the valve head is forced against the valve seat ring, obstructing the path of expired air to the connecting hose.

The upper outlet valve (2) consists of a rubber seat and a "lobe" secured between its four rubber pawls.

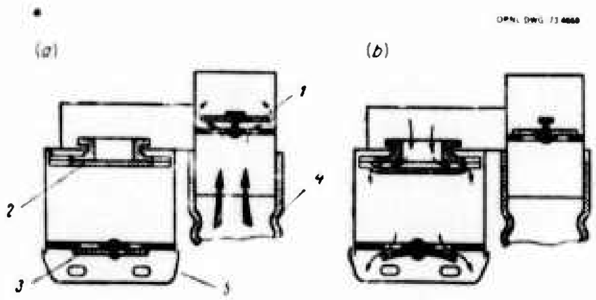

Fig. 32. Valve box: (*a*) Inlet; (*b*) outlet.

The valve lobe is unperforated, but the seat has a central aperture and bosses for mounting in the valve box.

The lower outlet valve (3) consists of a rubber disk with an aperture in the center for attachment to the valve seat. It is protected from possible damage by the separate screen (5).

Between the upper and lower outlet valve there is a chamber called the physiological chamber.

Both outlet valves open with expiration and close with inspiration. The valves operate as follows. With inhalation, air entering from the gas filter cartridge through the connecting hose raises the inlet valve and flows into the face mask. Due to a vacuum produced in the mask by inhalation, the outlet valve is pressed to its seat, and the latter obstructs the inlet of the ambient air under the mask through the valve box.

With expiration, increased air pressure is generated inside the mask. Thus the intake valve head drops down, is pressed against the valve seat, and obstructs the path of expired air in the connecting hose. Due to the air pressure, the disks of the intake valves are moved away from their seats, and the expired air leaves the mask.

The presence of the physiological chamber and the second outlet valve practically eliminates the possibility of inflow of contaminated air into the mask through the outlet valve.

The connecting hose connects the mask to the gas filter cartridge. It is made of rubber, covered with a fabric, and has transverse folds (corrugations) which guarantee air intake even when the tube is bent or accidentally compressed. The upper end of the tube is fastened to the outlet of the valve box, and the lower end is connected to the neck of the gas filter cartridge with nuts.

The gas mask bag is provided for storing and carrying the gas mask. It has two compartments: one (the smaller) for the gas filter cartridge and the other (the larger) for the face mask. Two wooden chucks are fastened to the bottom of the smaller compartment on which the gas filter cartridge is placed; the chucks prevent the aperture at the bottom of the box from being closed by the fabric of the bag during inhalation. There is a special "pencil" in the box to prevent the glass in the goggles from fogging up when the gas mask is operating. At the bottom, the bag is closed with a flap. A shoulder strap is sewn onto the bag for carrying the gas mask; there is a belt strap and a D-ring for fixing the bag to one's body during operation.

The GP-5 gas mask (see Fig. 30*b*) consists of a gas filter cartridge and a face mask. In addition, a gas mask bag and an anticondensation coating or special pencil to prevent the glass in the goggles from clouding are included in the kit.

The gas filter cartridge as well as the valve box of the GP-4Y gas mask are tin cylinders, around the inside of which there is a smoke filter, a special packing layer, and a dust filter. The gas filter cartridge of the GP-5 is half the size of the GP-4Y cartridge; the height of the cartridge is about 70 mm and its diameter is 107 mm.

The face mask of the GP-5 gas mask is made of rubber and has eye pieces, deflectors, and a valve box with inlet and outlet valves. The gas filter cartridge is screwed directly onto the valve box (without the corrugated connecting hose).

The helmet masks (SHM-62) come in five sizes, indicated on the chin part by the numbers 0, 1, 2, 3, or 4.

The design of the DP-6M and DP-6 gas masks is similar to that of the GP-4Y and consists of a gas filter cartridge and a MD-1 mask which comes in five sizes.

The DP-6M gas mask is designed for children from 1.5 to 12 years. These are supplemented by lighter D-11 cartridges and MD-1 masks only in the four smaller sizes. The D-11 mask has a design similar to the GP-4Y cartridge, differing only in its smaller size.

The DP-6 is designed for older children, supplemented by MD-1 masks in five sizes and GP-4Y boxes. The DP-6 and DP-6M gas mask bags differ only in size.

The MD-1 mask has eye pieces mounted in metal rings, a rubber valve box, a connecting hose, and a headpiece with a set of straps. It is made of rubber. The inlet valve is mounted on the valve seat of the nipple to which the connecting hose is attached. Two outlet valves are fastened to the plastic valve seat sockets mounted in the valve box so that a small chamber is formed between them. On the lower part of the valve box exterior there is a metal screen to protect the valves from mechanical damage. The connecting hose is hermetically fastened to the mask — at the side of the valve box for the smallest mask and higher on the valve box for the other sizes.

The child's protective chamber CPC-1 (see Fig. 30*e*) is designed for children up to 1.5 years old. It consists of a demountable wooden housing, a cover made of a rubberized fabric and a GP-4Y gas filter cartridge, a connecting hose, bellows, and straps. The casing of the chamber has a window permitting observation of the child's behavior inside the chamber, a sleeve-glove, a closing device for hermetically sealing the chamber, and inlet and outlet valves. The cover mounted over the housing forms a 50-liter chamber into which the child is placed. One end of the connecting tube is attached to a socket with an inlet valve on the chamber casing, and the other end is attached to the neck of the gas filter cartridge. The bellows are attached to the gas filter cartridge by rubber couplings and straps.

The protective chamber is hermetically sealed by a sealing valve. The purified air is pumped by the bellows. The chamber with the child is carried in the left hand. In addition, the bellows are placed on the right side, and the air is pumped with the right elbow.

To guarantee normal living conditions throughout the child's confinement in the chamber, it is necessary to pump air with the bellows (10 to 15 strokes) every 15 to 20 min, approximately in the rhythm of natural respiration.

Hopcalite cartridge. Civilian filter-type gas masks offer protection from all known TM, except carbon monoxide. When working in an atmosphere poisoned with carbon monoxide, a hopcalite cartridge is attached to the gas mask (Fig. 33); the cartridge is in the shape of a metal housing, the top of which has an externally attached neck piece (3) for attaching the case with the face mask connecting hose (or the mask helmet in the case of the GP-5), and the bottom has an internally attached neck piece (4) for attaching the gas filter cartridge to it.

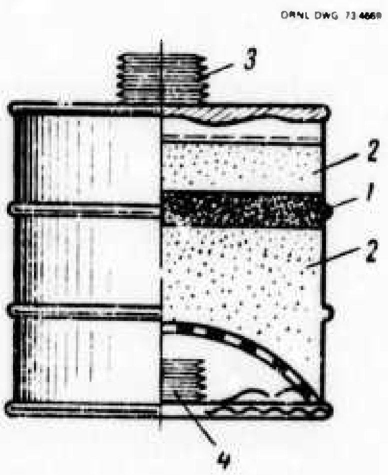

Fig. 33. Hopcalite cartridge.

The hopcalite (gas cartridge) is equipped with hopcalite (1) (a mixture of manganese dioxide and cupric oxide) and desiccant (2). The hopcalite catalyzes carbon monoxide oxidation to carbon dioxide with atmospheric oxygen. Desiccant (2) consists of silica gel impregnated with calcium chloride; it adsorbs water vapor from the air flowing through the hopcalite cartridge, protecting the hopcalite from moisture, because wet hopcalite loses its catalytic activity.

The initial weight is indicated on the hopcalite cartridge. When the weight increases 20 g or more due to moisture uptake, the cartridge cannot be used. The cartridge has a protective service life of about 2 hr.

To put the hopcalite cartridge into use, the following are attached to the gas mask: a connecting hose fastened by a nut (or GP-5 helmet mask) screwed to the external hopcalite cartridge neck piece and a gas filter cartridge screwed to the internal neck piece of the cartridge.

Selecting, fitting, and checking the gas mask. An efficient gas mask gives reliable protection only when the mask is correctly selected and carefully fitted to the face. To determine the required mask size, the length of the adult face must be measured (distance between the point of the largest depression at the bridge of the nose and the lowest point of the chin) as shown in Fig. 34.

The measurement may be made with a standard student ruler with millimeter divisions (Fig. 34*a*) or with calipers (Fig. 34*b*). After the face length is determined, it is necessary to determine the required mask size according to Table 11.

If the measured values are outside the limits of the given table, then the required mask size is determined by carefully testing a mask directly against the face. The mask selected must fit tightly against the face.

The helmet mask is selected according to the size of the head, which is determined by two measurements: the first along the closed curve passing through the crown of the head, the chin, and the cheeks (Fig. 35*a*) and the second one along the line connecting both ear canals and going through the arch of the eyebrows (Fig. 35*b*). The results of both measurements determine the size of the face mask according to Table 12.

The correctly selected helmet mask must fit tightly against the face and prevent ambient air from penetrating into the respiratory organs by passing the gas filter cartridge.

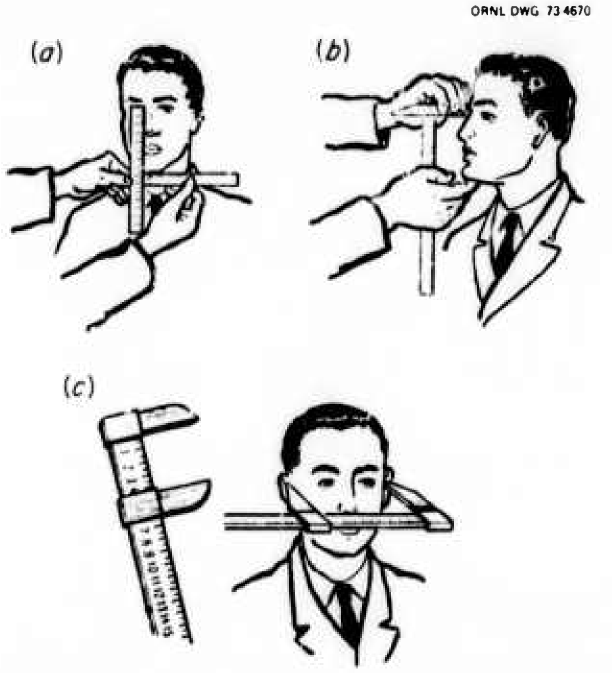

Fig. 34. Measuring the face to select a mask: (*a*) Measuring the length of the face with a ruler; (*b*) measuring the length of the face with calipers; (*c*) measuring the width of the face with calipers.

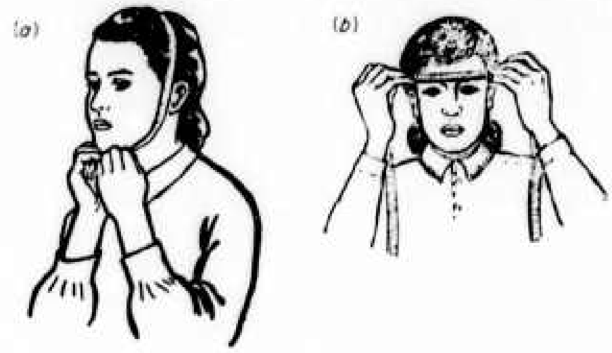

Fig. 35. Measuring the head for selecting the helmet mask of the GP-5 gas mask: (*a*) First measurement; (*b*) second measurement.

Table 11

Mask sizes	Face length (mm)
First	99–109
Second	109–119
Third	119 and higher

Table 12

Helmet mask sizes	Total of head measurements (cm)
0	up to 92
1	92–95.5
2	95.5–99
3	99–102.5
4	102.5 and higher

Table 13

Mask sizes	Face measurements (mm)	
	Height	Width
1	Up to 77	Up to 108
2	77–85	108–116
3	85–92	111–119
4	92–99	115–123
5	99 and higher	124–135

The size of a child's mask is determined in two ways. The first method is the same as the one for adults, that is, according to the length of the face. The second method is to measure the facial width (see Fig. 34*c*), the distance between the most strongly projecting points of the cheek bones. After the length and width of the face are measured, the required mask size is determined according to Table 13. If the measurements do not correspond to the data in the table, then the required size is determined by carefully fitting the mask to the child's face.

After the size of the mask is determined, it is necessary to carefully fit it to the face. To do this, it is necessary to completely extend the forehead straps, slip on the mask so that the center back of the mask lies at the center of the back of the head, and then tighten the straps at the forehead and back of the head (but not too much). Before putting on a new mask it is necessary to apply alcohol or a 2% Formalin solution to disinfect it.

When inspecting the gas mask, the following procedure is recommended:

1. check to see if the mask is complete with eye pieces, straps, valve box, valves, and protective screen;
2. check the condition of the connecting hose and the tightness of its connection with the valve box;
3. check the cannister case for dents, rust, punctures, ruptures, and integrity of the attached neck piece;
4. remove the plug closing the aperture;

5. examine the gas mask bag and check for the antifogging pencil for the glass, the baffles, the straps, and the buckles.

After examining it, set up the gas mask as follows: In the left hand take the nut of the connecting hose (letting the mask hang loosely) and with the right hand screw in the cartridge, taking care that there are no misalignments. Put the selected gas mask in the bag.

To put the mask away, take it in the left hand [holding it] behind the valve box so that the eye pieces are facing away [from you], with the right hand put the center of the rear part of the mask and the straps inside the mask, put the connecting tube into the bag, and then the mask with the valve box down.

To check the gas mask for airtightness, proceed as follows: Put the mask on, take the valve box out of the bag, close the aperture on the bottom with the palm of the hand, and take a deep breath. If air does not pass under the mask when [thus] inhaling, then the gas mask has been correctly selected and adjusted. If air does pass under the mask with inhalation, the gas mask is faulty and must be carefully checked.

When the mask has been checked, take a few breaths with the connecting hose and the valve box closed. To check the outlet valve, take a breath with the connecting hose compressed (covered). Also check the connecting tube with a breath, squeezing it at the neck piece of the gas filter cartridge.

To check the gas filter cartridge, it is necessary to remove the connecting tube, take the neck piece into your mouth, close the lower box aperture, and take a deep breath. If no air is admitted, then the box is airtight.

Finally, be sure the gas mask is in good condition; check the accuracy of assembly and adjustment in a room with irritating toxic materials under the supervision of experienced instructors and in the presence of medical workers.

Correct use of the gas mask. Depending on conditions, the gas mask is carried in one of three positions: "approach," "ready," and "combat" (Fig. 36*a*, *b*, *c*). In the absence of an immediate threat of nuclear, chemical, or biological attack by the enemy, the gas mask is carried in the approach position (Fig. 36*a*).

When there is an immediate threat of the use of weapons of mass destruction with an "air raid alert" signal or on command "gas masks ready," the gas mask is carried in the ready position (Fig. 36*b*). To transfer the gas mask to the ready position, it is necessary to unfasten the flap on the bag, take out the strap, bring it around the body, and tie it to the D-ring on the bag.

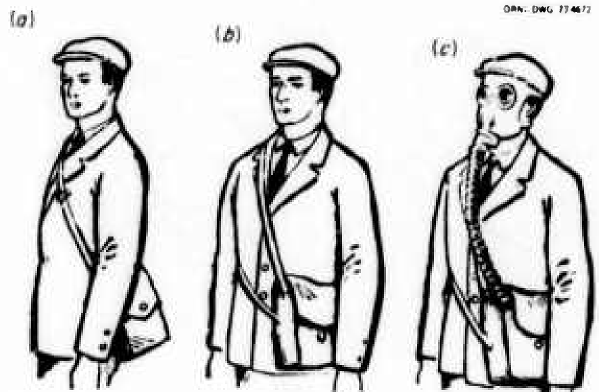

Fig. 36. Carrying the gas mask: (*a*) "Approach" position; (*b*) "ready" position; (*c*) "combat" position.

The gas mask must be fastened so that it does not shift to one side.

The gas mask is shifted to the combat position (Fig. 36*c*) when the nuclear blast occurs, [or] in response to the signals "chemical attack," "radioactive contamination," "biological contamination," or on the command "gases." The gas mask is shifted to the combat position as follows: cease breathing and close the eyes; take the head piece and place it to one side or hold it between the legs; remove the mask from the bag and, taking the forehead and head straps in both hands (with the thumb in), place the lower part of the mask on the chin and tighten the mask on the face, guide the head straps behind the ears; take the free ring of the head straps in the hand and tighten it so that the mask rests snugly against the face (Fig. 37*a*). After this it will be necessary to exhale strongly, open the eyes, recommence breathing, and slip on the head piece.

A closer examination of all ways for putting on the gas mask is obligatory. Holding the breath and closing the eyes protects from the effects of toxic materials until the gas mask has been put on, and a strong expiration after putting on the mask forces out all contaminated air which has penetrated while the gas mask was being put on.

The gas mask is removed at the signal "retreat," at the command "take off gas masks," and when it is certain that the danger has passed.

To remove the gas mask, it is necessary to raise the head piece with the right hand, take hold of the valve box with the left hand, pull the mask down slightly with a forward movement of the arm, and then, with a downward movement, take off the mask (Fig. 37*b*). After this, slip off the head piece, rub off or dry off the mask, and put it back in the bag.

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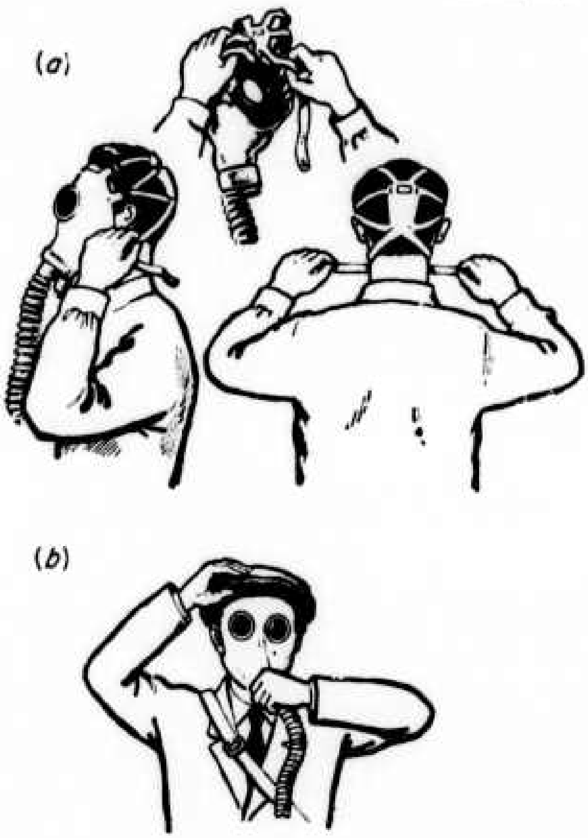

Fig. 37. Examples: (*a*) Putting on the GP-4Y gas mask; (*b*) taking it off.

To put on the GP-5 helmet mask, it is necessary to grasp the lower part of the reinforced edge with both hands so that the thumbs are on the outside and the other fingers are inside; place the lower part of the helmet mask under the chin and with a quick upward and backward movement of the hands draw the helmet mask onto the head so that there are no creases and the eye pieces are directly in front of the eyes.

To remove the gas mask, with the valve box in the left hand, the helmet mask must be drawn down slightly and removed with a forward and upward movement of the arms.

The rules for using, storing, and preserving the GP-5 gas mask are the same as for the GP-4Y gas mask.

When using the gas mask under winter conditions, it is possible that the rubber may become roughened, the lobes of the outlet valve may freeze or they may freeze to the valve box, and moisture may congeal on the glass of the eye pieces and inside the connecting tube. These possibilities make the use of the gas mask more difficult and may result in operating failure. To prevent such things from happening, it is necessary in a noncontaminated atmosphere to periodically warm up the face mask by putting it under one's overcoat and, under combat conditions, periodically warm up the valve box with the hands, simultaneously blowing on the valves.

When a heated room is entered from the cold, the gas mask may be covered with moisture for 10 to 15 min. If so, wipe it dry and blow through the valves. Sometimes ice forms in the connecting hose; if so, it must be unscrewed from the box, carefully washed out, and pieces of ice shaken from it.

Using a defective gas mask. When a gas mask is damaged in a contaminated atmosphere, it must be replaced at once with a properly functioning one, or shelter must be sought. If this cannot be done right away, then the damaged gas mask must be used for a certain period of time.

When TM "breakthroughs" (leaks) are detected, the cause of malfunction must be found. Sometimes the gas mask admits TM through gaps in the hermetic sealing between the connecting hose and the gas box, or the gas mask does not fit tightly against the face; so it is necessary first to check the nut on the connecting hose and tighten the head straps.

When a mask is torn, it is necessary to close the tear tightly with the fingers or with the palm of the hand. In the case of a large rip in the mask or damage to the glass, it is necessary to close one's eyes and hold one's breath, then take off the mask, unscrew the connecting hose, take the neck piece of the gas filter cartridge in the mouth, hold one's nose and breathe only through the mouth, not opening the eyes. The same is done when the connecting hose is damaged. When the gas filter cartridge is damaged, it must be replaced.

When replacing the damaged gas mask in a contaminated atmosphere, it is necessary to:

1. hold the breath, close the eyes, and take off the damaged gas mask;
2. put on a properly operating gas mask, exhale sharply, and then resume breathing;
3. place the box of the correctly functioning gas mask in its own bag and the damaged box in the bag from which the correctly functioning gas mask was taken.

Preservation of the gas mask. The gas mask gives reliable protection from TM only if it is handled carefully and stored properly. It may quickly become dysfunctional due to careless handling and incorrect storage. To ensure the protective properties of the gas mask, it is necessary to protect it from shocks, jolts, and strong vibrations and not allow moisture to penetrate the box; to refrain from drying or storing it near stoves or other heaters; to handle the outlet valves carefully, protect them from plugging up and freezing, and carefully blow them out when they do freeze up; to keep the gas mask assembled in the bag, suspended on a strap or lying on a shelf with the bottom down; during long-term storage, the aperture in the bottom of the valve box must be closed with a rubber plug.

The gas mask must not be lubricated with technical grade oil or stored near volatile liquids (kerosene, gasoline, acetone, etc.), nor should foreign objects be stored in the gas mask bag or the gas mask be used as a pillow.

Checking the gas mask in a fumigation chamber. The final check of the working condition of the gas mask, correct assembly, and fit is made in a chamber (installation) with a training irritant. Personnel who know the properties of the irritant and are familiar with the design and correct use of the gas mask are permitted to test the gas mask in a gas fumigation chamber. Suitable individual vertical chambers for checking the gas mask are those that are free of cracks, with tightly closing doors. There must be artificial or natural illumination in the chamber, and the arrangement of the doors must guarantee fast evacuation of personnel who experience eye irritation. Chloropicrin is used as the training irritant.

The working condition of the gas mask is determined by two checks. The first check is to determine the working condition of the face mask. The test is carried out in the presence of concentrated chloropicrin vapors, 0.85 g/m^3, which form 0.5 cm^3 vapor from liquid chloropicrin per cubic meter of chamber. The second check is to finally determine the working condition of the face mask and the overall service condition of the gas mask as a unit. The test is carried out in the presence of concentrated chloropicrin vapors of 8.5 g/m^3 which form 5 cm^3 of vapor from the liquid chloropicrin per cubic meter of chamber. The personnel remain in the chamber with the irritant for 5 min in each test.

To check the mask selection in first and second concentrations of chloropicrin vapors, it is necessary to shake one's head up and down a few times while wearing the gas mask, turn and incline the head right and left, and then squat several times.

People experiencing eye irritation while testing the gas mask should immediately leave the fumigation chamber and, after checking the gas mask outside of the chamber, continue the check inside the fumigation chamber.

After the exit of each group from the fumigation chamber, it is necessary to evaporate the additional chloropicrin equal to 20% of the original amount. After five of these changes in the chamber, the chloropicrin chamber is ventilated, and the necessary chloropicrin concentration is again produced in it.

The face mask is considered to be a good fit and the gas mask in good operating condition if no eye irritation occurs during the test at a concentration of 8.5 g/m^3.

Fumigation is carried out by supervisors and instructors in the presence of medical workers (doctors or surgeons' assistants). The fumigation supervisor takes a group, explains to them the sequence of operations, regulates the sequence, takes safety measures during the operating period, and gives signals for the order of changes in the fumigation chamber.

Immediate supervision of checking the gas masks and producing the necessary concentration of chloropicrin vapors in the chamber is done by the instructor, who conducts the next group into the chamber, sees to it that the necessary precautionary measures are carried out, and conducts the group out of the chamber to complete the test.

When the group has been led out of the chamber, the instructor dismisses them for a few minutes to remove the chloropicrin vapors from their clothes, after which they are permitted to remove their gas masks.

4.1.3 Air-Supplied Devices and Gas Masks

Unlike filter-type gas masks, air-supplied apparatus and gas masks completely isolate the respiratory system from the ambient atmosphere. Breathing is sustained with self-contained oxygen in compressed form or in the form of chemical compounds.

Air-supplied devices (gas masks) are used when filter-type gas masks cannot guarantee reliable protection, namely: in high TM concentrations, when the gas adsorption packing of the filter-type gas mask becomes rapidly saturated and TM penetrate the mask, that is, the gas mask allows rapid "breakthrough" of toxic material; when working with unknown TM that are not retained very well by the filter-type gas mask; with an oxygen-deficient atmosphere, for example, when extinguishing fires.

Air-supplied devices (gas masks) include: the oxygen-supplied device KIP-5, the oxygen-supplied gas masks KIP-7 and KIP-8, and the air-supplied gas masks IP-46 and IP-46M.

In the KIP-5, KIP-7, and KIP-8 masks, air necessary for breathing is freed of carbon dioxide gas in the regeneration cartridge and enriched in the breathing bag with oxygen from the oxygen bottle; in the IP-46 and IP-46M gas masks, air necessary for breathing is freed of carbon dioxide gas and enriched with oxygen directly in the regeneration cartridge which is equipped with a special material.

The oxygen-supplied KIP-5 device. *Operating principle and designation of KIP parts.* The face mask (1) of the KIP-5 (Fig. 38) isolates the respiratory system and the face from the surrounding atmosphere and is in the form of a mask with straps, or a helmet mask.

The valve box (2), which contains a mica inlet and outlet value, is designed to direct the flow of inspired and expired air.

The regeneration cartridge (9) is designed to purify the expired air of carbon dioxide gas and moisture. It is a tin box filled with a lime adsorber. There are vents in the top and bottom of the cartridge. A connecting tube for exhalation (11) and a lower junction box (8), joined to the regenerative cartridge with a breathing bag (6), are fastened to the upper and lower vents, respectively. The operating time of the cartridge is about 2 hr. An interruption in operation does not affect the protection afforded by the chemical absorber. The cartridge must not be changed while the device is in operation.

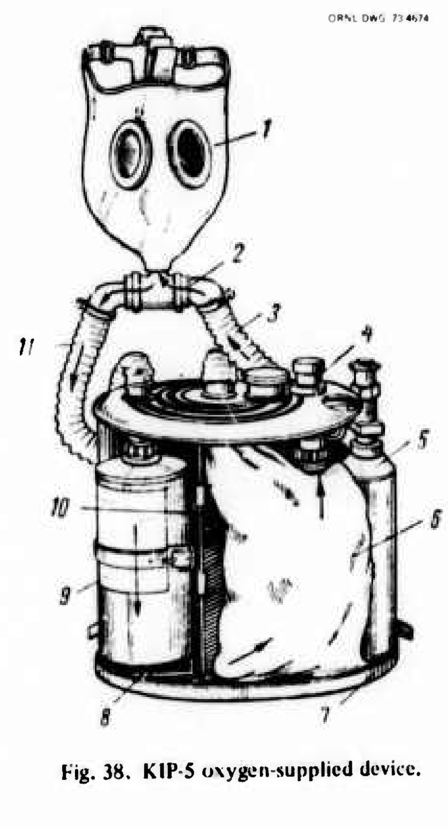

Fig. 38. KIP-5 oxygen-supplied device.

The breathing bag (6), capacity approximately 5 liters, is a reservoir for the required quantity of air, which is enriched with oxygen to guarantee normal breathing for the individual.

The inhalation connecting hose (3) and combined oxygen feed mechanism (4) are connected to the upper part of the breathing bag, and the lower junction box (8) is fastened to the lower part, as described above. The overpressure valve (10) is fastened to the wall of the breathing bag, which is designed to automatically release excess air from the breathing bag when necessary.

The lower junction box connects the regeneration cartridge with the breathing bag, collects moisture flowing out of the regeneration cartridge, and cools the air passing through it.

The oxygen bottle (5) is designed to store the oxygen supply. The capacity of the bottle is 0.7 liters, and its weight is 2.1 kg. The maximum oxygen pressure in the bottle is 150 atm. The oxygen supply in the bottle (150 liters) is sufficient for 45 to 60 min of breathing. The oxygen bottle may be replaced while operating the device without leaving the contaminated area. A valve is installed on the bottle to control the oxygen feed to the breathing bag.

The mechanism for continuously supplying oxygen into the breathing bag consists of the reducing valve, the bypass, the automatic lung, and the miniature pressure gage (pheninneter).

The housing (7) is a metal box with two compartments: the right compartment is for the breathing bag and the oxygen flask; the left is for the regeneration cartridge. Both compartments are closed with hinged lids. Belt and shoulder straps are fastened to the housing for carrying the device. The mask and spare parts are kept in the instrument bag, which is carried on a belt strap.

The oxygen-supplied gas masks KIP-7 and KIP-8 are designed and operate in the same principle as the KIP-5, except that the oxygen bottle capacity of the KIP-7 is 1 liter; in the case of the KIP-8, it is 2 liters, making it possible to work for a longer period of time.

The air-supplied gas masks IP-46 and IP-46M. The working principle of the IP-46 and IP-46M air-supplied gas masks is based on the fact that the air required for breathing is cleansed of carbon dioxide gases and is enriched with oxygen in the regeneration cartridge which is equipped with a special substance.

The IP-46 air-supplied gas mask (Fig. 39) consists of a face mask (1) a regeneration cartridge (5) with a starting device, a breathing bag (7) with an overpressure

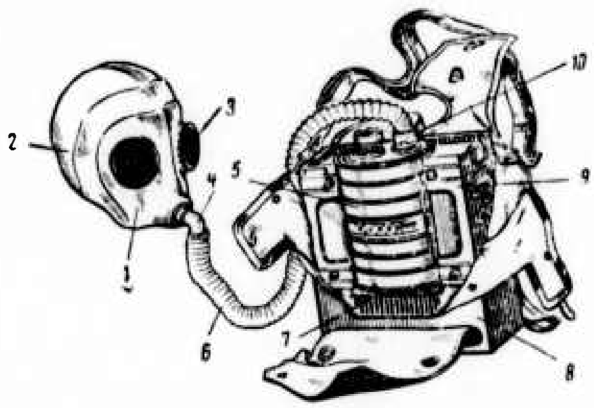

Fig. 39. IP-46 air-supplied gas mask.

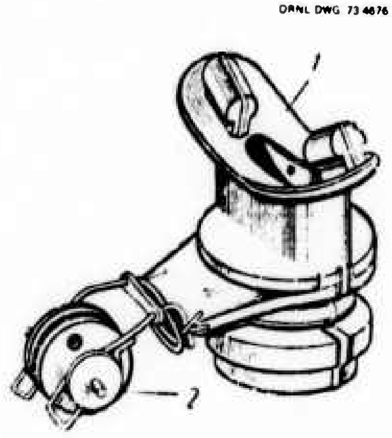

Fig. 40. Components of the air-supplied gas mask: (1) mouthpiece; (2) nose clip.

valve, a housing (9), and a bag (8). In addition, the air-supplied gas mask unit includes a mouthpiece with a nose clamp, a spare starting briquet for the cartridge, a box with ampuls, a box with an antiperspiration film, and a combination wrench.

The face mask of the air-supplied gas mask feeds the purified air to the respiratory system, directs the expired air into the regeneration cartridge, and also protects eyes and face from toxic materials in the air. It consists of a rubber cap (2) with eye pieces (3), a connecting piece (4), and a connecting hose (6) with nipples (10) designed to connect the hose with the regeneration cartridge.

The mouthpiece (Fig. 40) connects the respiratory system of the individual with the connecting piece of the face mask. The presence of a corrugated extension piece on the mouthpiece makes it possible to hold it in the mouth more comfortably and more reliably. A nose clip is attached to the mouthpiece baffle plate which prevents entry of air into the nose. The mouthpiece (1) and nose clip (2) are used only for underwater operation.

The regeneration cartridge (5) (see Fig. 39) provides the oxygen required for breathing and absorbs moisture and carbon dioxide gas in expired air. It consists of a housing containing oxygen-rich compounds, two lids with neck pieces, and a starting device. In the assembled gas mask, the regeneration cartridge is placed in the housing pocket.

The starting device is designed to trigger the regeneration cartridge and consists of a starting pellet set in a glass container with a handle, glass ampuls with acid, a rubber diaphragm, and a nut tightened with a cap. The starting pellet generates the oxygen required for breathing when the gas mask is first put into use and triggers the regenerating cartridge. The briquet operates for a maximum of 2 min and is protected in a special case.

The detachable heating jacket is designed to decrease heat loss from the regeneration cartridge and is used for operation in water and for low air temperatures on dry land.

The breathing bag (Fig. 39) serves as a reservoir for expired air and oxygen produced by the regeneration cartridge. It is made of rubber and has inverted flanges, two in the IP-46 and four in the IP-46M. The following are attached to the inverted flanges: a nipple for attaching the breathing bag to the regeneration cartridge, an overpressure valve, and in two flanges of the IM-46M gas mask [there are] two devices for additional oxygen supply. The breathing bag has lugs for attaching it to the housing.

The overpressure valve consists of forward and check valves which are mounted in one housing. The forward valve automatically releases excess oxygen from the breathing bag; the check valve prevents the entry of ambient air or water into the breathing bag if a negative pressure exists and if the forward valve is accidentally opened.

The housing (see Fig. 39) is made of Duralumin and protects the breathing bag from compression and mechanical damage. The regeneration cartridge, the breathing bag, and the sack are fastened to the housing. The sack (see Fig. 39) is used to protect and to carry the air-supplied gas mask.

The IP-46M gas mask differs from the IP-46 air-supplied gas mask by the presence of two devices for additional oxygen feed, a heating jacket, and a shorter connecting hose. The devices for feeding in additional oxygen in the IP-46M mask inflate the breathing bag with oxygen if it is suddenly immersed in water or if there is an oxygen deficiency in the breathing bag upon inhalation or upon depletion of the regeneration cartridge.

To convert the gas mask to the "combat" position for operation on dry land, one should: hold the breath and close the eyes (when in contaminated air); remove the hat; unfasten the upper right flap of the bag, take out the helmet, and put it on the head so that there are no wrinkles and the eye pieces are aligned with the eyes; ensure that the helmet is on right, correct the misalignments and the wrinkles, if any, exhale sharply, open the eyes, and resume breathing; remove the pin and press down on the diaphragm of the starter; in addition, it is also necessary to listen for the crunch of broken glass of the ampuls, and the tightened nut must heat up; if there is no heat, repeat the process until the ampuls break; replace the hat.

When the starter ampuls are broken, oxygen reaches the starting briquet, causing decomposition of its surface; further decomposition of the briquet takes place spontaneously, proceeding from one layer to another.

Oxygen generation begins due to the effect of water vapor and heat on the substances in the regeneration cartridge. Further generation of oxygen takes place because the carbon dioxide and water vapor exhaled are absorbed by the material in the regeneration cartridge. Generated oxygen and exhaled air enter the breathing bag. Upon inhalation, air from the breathing bag goes through the regeneration cartridge and the connecting tube below the helmet and then reaches the respiratory organs.

When preparing to operate the IP-46M gas mask underwater, the mouthpiece must be taken into the mouth (the lips of the mouthpiece must be between the teeth and the extension piece must be between the lips and the gums), and the nose must be closed with the nose clip so that its spiral rests against the mouthpiece baffle plate before the gas mask is put on.

When using the air-supplied gas mask, it is necessary to take the limited protective capability of the regenerating cartridge into account. The moment the regenerating cartridge ceases to operate, the oxygen generated by it is insufficient for respiration. The period just before the regenerating cartridge is exhausted is characterized by incomplete filling of the breathing bag and collapse of its walls upon inhalation as well as heating of the lower parts of the regeneration cartridge. The exhausted regeneration cartridge is replaced with a new one. As a rule, the replacement is made in noncontaminated air. Caution is indicated when handling an overheated regeneration cartridge since handling may result in burns.

Since they operate in an atmosphere of low oxygen concentration (less than 16 to 18% by volume) or in an atmosphere contaminated with toxic materials (of types that are not absorbed by the skin*), oxygen respirators [RKK-1, RKK-2 (RKK-2m), Ural-1, Lugansk-2, Donbass-2] may be used by the mountain rescue service, as may oxygen safety devices (SK-3, SK-4, and others).

In design and operating principle, the oxygen respirators are similar to the IIP-5. The oxygen respirators (except for the RKK-1) and self-renewing units do not have a helmet mask, and they use a mouthpiece with a rubber extension piece and a nose clip. The basic data concerning the oxygen respirators and the self-renewing units are presented in Table 14. Only well-trained healthy people are permitted to use the oxygen-supplied devices.

Table 14

Oxygen respirator	Technical characteristics: Weight of equipped device (kg)	Capacity of oxygen bottle (liters)	Service life protective (hr)
RKK-1	7.4	1	2
RKK-2 (RKK-2M)	11.5 (11.9)	2	4
Ural-1	11.5	2	4
Lugansk-2	12	2	6
Donbass-2	13.4	2	6
SK-3 self-renewing	3.8	0.4	1–2.5

4.1.4 The Most Simple Means for Protecting the Respiratory System

To protect the respiratory system from radioactive dust, it is possible to use dust-protective respirators of different types, cotton gauze, and other bandages in addition to the filter-type gas mask and the air-supplied devices and gas mask. These respirators are designed to protect the respiratory organs from harmful aerosols. They are usually made in the form of a face mask (full or half mask) on which filtering elements are mounted. In some types of respirators, the material of the face mask has filtering properties; thus the entire face mask is a filtering element.

*Toxic materials that are absorbed by the skin penetrate the skin into the bloodstream.

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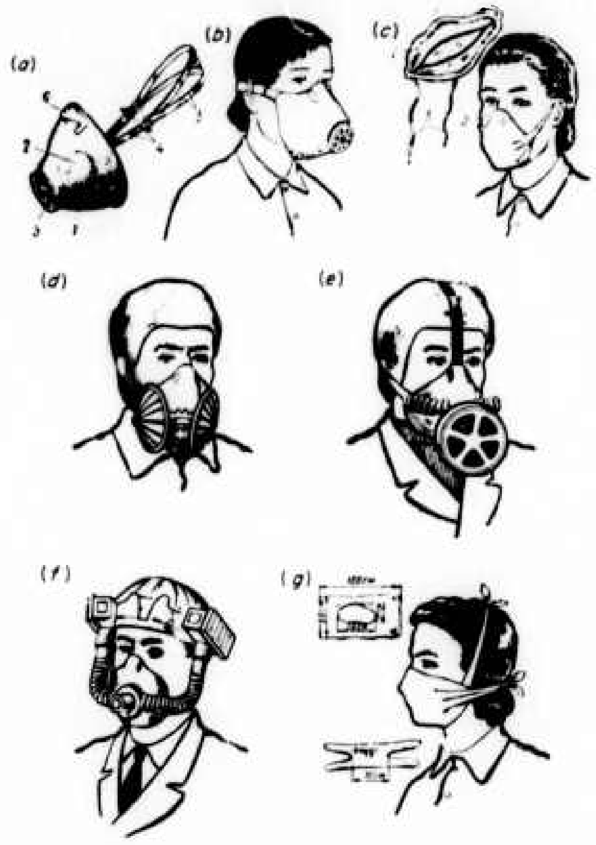

Fig. 41. Respirators: (*a*) R-2 (general view); (*b*) R-2 in "combat" position; (*c*) SHB-1 "Petal"; (*d*) RPP-57; (*e*) PRB-5; (*f*) PRSH2-59; (*g*) cotton-gauze bandage (sling).

Industry is manufacturing several types of respirators: R-2, SHB-1, RPP-57, PRB-5, and PRSHB-59. The R-2 respirator (Fig. 41*a*) consists of a filtering half mask (1) equipped with two inlet valves (2); one inlet valve has a protective screen (3), a headband (4) consisting of elastic and inelastic straps (5), and a nose clip (6). The R-2 respirator is kept in a polyethylene package with a ring.

The outer part of the half mask is made of polyurethane (a porous, synthetic material), and the inner part is made of a thin, air-impermeable layer, in which the inlet valves are mounted. There is a polymer fiber filter between the polyurethane and this layer. Inspired air passes through the entire external surface of the polyurethane and the filter, is cleansed of dust, and passes through the inlet valves into the respiratory organs.

Expired air passes to the atmosphere through the outlet valve. The R-2 respirator comes in three sizes, which are designated on the inner chin part of the half mask and on the label on the polyethylene packet. These sizes correspond to the mask sizes of the GP-4Y, since the respirator is designed like the gas mask, according to the same measurements as listed in Table 11.

After the respirator is selected the face mask is put on and checked for an airtight fit. To put on the respirator, one must: remove the respirator from the package by cutting (tearing) the edge of the upper welded seam of the package and carefully opening the package; put the half mask over the face so that the chin and the nose are inside (Fig. 41*b*); put on the head band so that one inelastic band goes completely around the parietal part of the head and the other around the back of the head; if necessary, adjust the length of the elastic strap with the buckle, so that it is not necessary to remove the half mask and then replace it; press the ring of the nose clip to the nose.

To avoid discomfort when putting on the respirator, the half mask should not be pressed vigorously against the face or the nose clip forcibly compressed.

To check the tightness of fit of the mask when it has been put on, it is necessary to tightly close the opening of the protective screen over the inlet valve with the palm of the hand and exhale slightly. If no air escapes where the respirator is in contact with the face but only inflates the half mask, the respirator is airtight; if an air flow is felt along the outside of the nose, the nose clip ring must be pressed tightly to the nose. If the respirator cannot be made airtight, another size must be tried. After checking the fit of the respirator half mask, return it to the package and close it with the ring, as when storing in the bag.

When putting on the R-2 respirator, it is necessary to remove one's hat. Take the respirator out of the bag and the package and put it on in the order indicated above, but place the package in the bag. Then replace the hat.

When using the respirator, it is necessary to check periodically the tight fit of the half mask against the face. To remove moisture coming through the outlet valve onto the mask surface, it is necessary to bow the head forward. If there is sufficient accumulation, the respirator may be removed for 1 to 2 min, the moisture poured from the inside chamber of the half mask, the inner surface wiped off, and the respirator replaced.

After removing the respirator (when used under conditions of radioactive contamination), it must be decontaminated by removing dust from the outside of the half mask by scraping with a stick (brush) or carefully knocking it against some object. The inside surface of the half mask can be rubbed with a damp cloth (rag), but the mask should not be turned inside out. Then the respirator is replaced in the package, closed with the ring, and put back into the bag.

A good method of protecting the respiratory system from radioactive dust and aerosols is the SHB-1 "Petal" respirator (Fig. 41*c*). It is made of special material, has high filter efficiency, and is intended for one-time use. Total weight is about 10 g.

The SHB-1 respirator consists of housing (1), rubber cord (2), aluminum plate (3), plastic cross bar (4), and two straps (5). To use the respirator, remove it from the package, pull the ends of the rubber cord out to the required length, tie them securely with a simple knot, cut off the rest of the rubber cord, and set the prepared lengths and the knot inside the rim of the respirator, which is uniformly covered with rubber. To don the respirator, begin with the chin; then, while stretching the rubber cord, place the upper edge on the bridge of the nose, squeeze the aluminum plate into the shape of the bridge of the nose, and then tie the straps freely behind the head without stretching them; straighten the edge of the respirator with a slight movement of the fingers, pressing it tightly to the face. The plastic cross bar maintains the hemispherical shape of the respirator and prevents the filter from drawing under the lips when inhaling. A correctly adjusted respirator keeps out up to 99.9% of the dust.

The RPP-57 respirator (Fig 41*d*) consists of a rubber half mask, two metal filter boxes, and an outlet valve box. The half mask has three apertures, two at the sides and one in the lower part. A filter box is mounted in the side aperture and the outlet valve box in the lower one. The filters are made of filter cardboard. The filtering efficiency of the respirator for dust is about 99%. It has a knitted covering to prevent face irritation and to improve the airtight seal of the rubber half mask where it contacts the face. An aluminum strap is fastened on the bridge of the nose part of the mask, which is squeezed to conform to the shape of the nose so that the half mask fits tightly against the face. The head band holding the respirator to the head is adjusted with movable clasps.

The PRB-5 respirator (Fig. 41*e*) offers almost complete protection of the respiratory system from radioactive dust. It consists of the rubber half mask with valves, the housing, the dust filter, and the head piece. The half mask has four flaps. Aluminum or plastic seats are mounted in the two side flaps for the rubber lobes of the outlet valves. The respirator housing and the filter are attached in the first flap. A rubber outlet valve is fastened in the chin flap, which is designed to remove the moisture which collects under the half mask.

Metal rings are fastened to the half mask to connect the head parts. The head gear is a system of elasticized fabric tapes, which have buckles to regulate their length behind the head, at the temple-parietal region, and two at the cheek.

The respirator housing is a circular aluminum or plastic cartridge with the inlet valve seat in the lower part. There is a thread on the housing for screwing on the top which holds the filter in place in the cartridge. The filter is made of corrugated strips of a special activated filter which has high efficiency and low flow resistance to respiration.

The PRSH2-59 (Fig. 41*f*) respirator is designed for work in mines and shafts with a high dust content. The respirator consists of a rubber half mask and two housings with filters. The filter housings are attached to the head piece by rubber straps and connected to the half mask with short corrugated hoses. There is a knitted seal over the edge of the rubber half mask.

The filter housing is a rectangular plastic box with rounded sides and corners, with nozzles for connecting the corrugated hose. Inlet valves are mounted where the corrugated hose is connected to the half mask. The exhalation valve is located in the forward part of the half mask over the discharge valve, for drawing off condensed moisture.

The most simple means of protecting the respiratory system is the cotton gauze bandage. It is made of a piece of cotton gauze 100 × 50 cm. The gauze is spread on a table and a piece of cotton of uniform thickness with dimensions of 30 × 20 cm and thickness 1 to 2 cm is placed in the center. Both edges of the gauze are folded over the cotton. The remaining ends of the gauze are cut longitudinally, 25 to 35 cm from each end, for tying. When the bandage is put on, it must cover the chin, mouth, and cheeks up to the lower eye lid. The split ends of the bandage are tied: the upper ones behind the neck, the lower ones on the parietal region (over the head) (Fig. 41*g*). Cotton must be inserted where the bandage bulges from the bridge of the nose and the cheeks.

To protect the eyes when wearing a respirator or the cotton gauze sling, dust-proof goggles should be worn.

4.2. DEVICES FOR PROTECTING THE SKIN

4.2.1 Special Devices for Protecting the Skin

Skin protective devices protect exposed parts of the body, clothes, footwear, and equipment from contamination by radioactive substances and biological media as well as from vapors and drops of TM. In addition, they completely stop alpha radiation and

Fig. 42. OP-1 protective clothing: (*a*) Arms in sleeves; (*b*) cloak; (*c*) worn as coverall.

attenuate to a large degree the effect of the beta particles. Skin protective devices are classified into isolation and filter types, according to the type of protective effect.

Isolation skin protective devices are made of air-impermeable materials, usually special rubber and fireproof rubberized fabrics; they may be airtight or nonairtight. The airtight types enclose the body entirely and protect it from TM vapor and drops; nonairtight types protect only from TM drops. The isolation skin protective devices include general troop gear and special protective clothing.

The filter-type skin protective devices are cotton and linen fabrics impregnated with special chemicals. The fabric fibers are impregnated with a thin chemical coating, while the interstices between fibers remain free; because of this, the air permeability of the material is largely maintained, and TM vapors are adsorbed when contaminated air passes through the fabric. Filter-type skin protective devices may be ordinary clothing and linen, impregnated, for example, with a soapy-oily emulsion.

The isolation skin protective devices — general troop protective gear and special protective clothing — are basically designed to protect CD personnel when working in contaminated areas. General troop protective gear consists of a protective coat, stockings, and gloves. Because of the incompleteness of airtight sealing against TM vapors in all protective clothing, as a rule the gear is used in combination with impregnated clothing and underwear.

The protective coat (Fig. 42) is made of special rubberized material; it has two flaps, sleeve fastenings, and a hood, as well as straps and other fastenings,

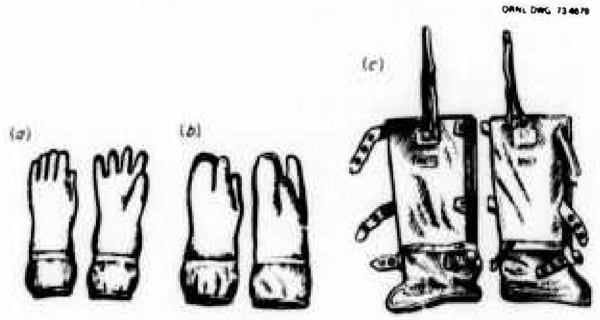

Fig. 43. (*a*) Protective gloves with five fingers, (*b*) with two fingers, and (*c*) leggings.

making it possible to wear the coat in a variety of manners. The coat fabric assures protection from TM, radioactive substances, and bacterial media, as well as from thermal radiation. The weight of the protective coat is about 1.6 kg. The protective coat comes in five sizes: the first for persons with a height up to 165 cm, the second for 165 to 170 cm, the third for 170 to 175 cm, the fourth for 175 to 180 cm, and the fifth for >180 cm.

The protective gloves are made of rubber, with the cuffs made of impregnated fabrics.* There are two kinds: summer and winter (Fig. 43*a* and *b*). The summer gloves have five fingers, and the winter gloves two, with a warm button-in lining. The weight of the protective gloves is about 350 g.

The protective leggings are made of rubberized fabric (Fig. 43*c*). The soles are reinforced with canvas or rubberized material. The leggings with a canvas base material have two or three straps for fastening to the leg and one strap for fastening to the belt; leggings with a rubber material are fastened to the legs with straps and to the belt with bands. The weight of the protective leggings is 0.8 to 1.2 kg.

When work is done in contaminated areas, the protective coat is used in coverall form (see Fig. 42*c*).

Special protective clothing includes: a light protective suit, a one-piece protective coverall, a protective ensemble consisting of a jacket and trousers, and a protective apron.

The light protective suit (Fig. 44) is made of rubberized fabric and consists of a hooded jacket (1), trousers (2) sewn to the leggings, mittens (3), and a cowl (4). In addition, the outfit includes a bag (5) and an extra pair of gloves. The weight of the protective suit

*A fabric impregnated with special chemicals which increase its barrier effects for TM vapors.

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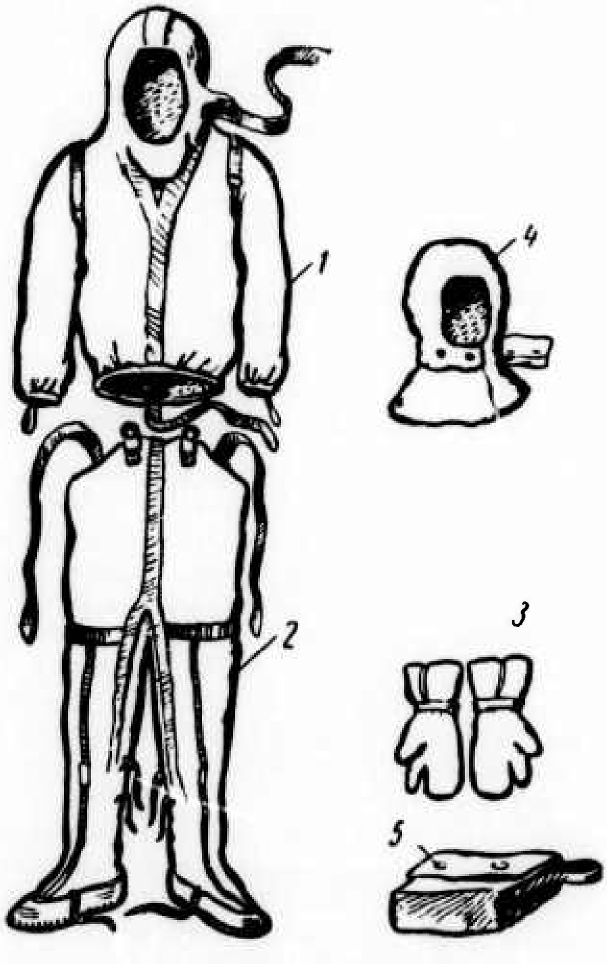

Fig. 44. "L-1" light protective suit.

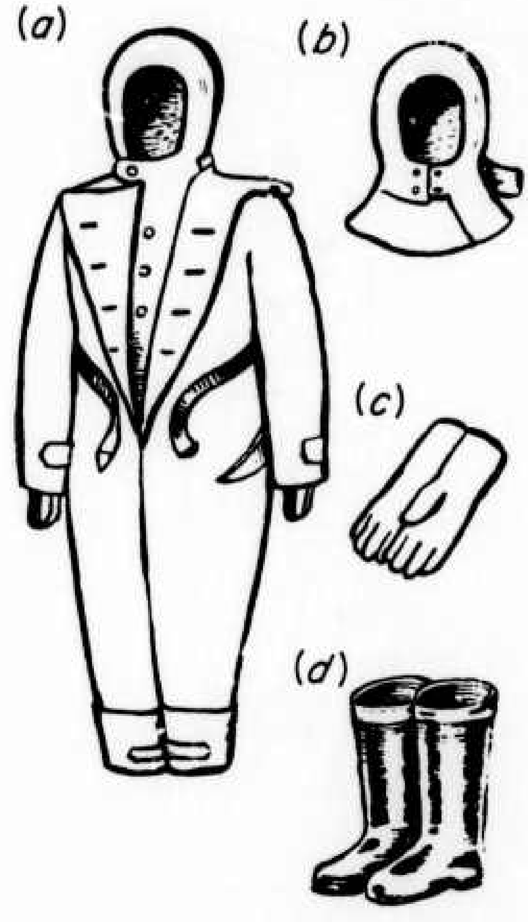

Fig. 45. Protective coverall, boots, and gloves.

is about 3 kg. The suit comes in three sizes: the first for people up to 165 cm, the second for 165 to 172 cm, and the third for >172 cm.

The protective coverall (Fig. 45*a*) is made of rubberized fabric. It comes with the trousers, the jacket, and the hood sewn in one piece. The coverall comes in the same three sizes as the light protective suit. The coverall is used with the cowl (Fig. 45*b*), the gloves (Fig. 45*c*), and the rubber boots (Fig. 45*d*). The rubber boots come in sizes 41 to 46. The five-fingered rubber gloves come in one size. The cowl is a hood with a cape, made of emulsion-impregnated fabric. The weight of the protective coverall, including boots, gloves, and cowl, is about 6 kg.

The protective ensemble (Fig. 46), consisting of a jacket and trousers, differs from the protective combination only in that its component parts are made separately. The set includes rubber gloves, boots, and cowl.

The protective apron is made of a rubberized fabric and is used with the protective stockings and the rubber gloves for degassing, decontamination, and disinfection of transport and other equipment in a contaminated area. All aprons are one size; the weight of the apron is 400 g.

4.2.2 Rules for Using Protective Clothing

A person dressed in the protective jumpsuit (or in the protective ensemble), rubber boots, rubber gloves, and a gas mask is completely isolated from the ambient atmosphere, and so natural heat transfer is inhibited; if the rules for remaining in the protective clothing are not observed, overheating (heat stroke) may occur.

Thus, to protect the working ability of personnel at the specified air temperature, the protective clothing must be worn as indicated:

+10°C and above, over underwear;

from 0 to +10°C, over underwear and summer clothing;

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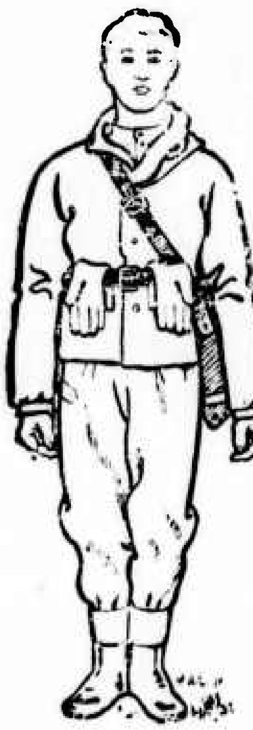

Fig. 46. Protective ensemble.

Table 15

Ambient air temperature (°C)	Work periods in isolating [tight-fitting] clothing	
	Without wetted cotton coverall	With wetted cotton coverall
+30 [86°F] and higher	Up to 20 min	1.0–1.5 hr
+25–+29 [77–85°F]	Up to 30 min	1.5–2 hr
+20–+24 [68–76°F]	Up to 50 min	2.0–2.5 hr
+15–+19 [59–67°F]	Up to 2.0 hr	Longer than 3 hr
Below +15 [59°F]	Up to 4–5 hr	

from 0 to −10°C, over underwear and a winter suit;

below −10°C, over underwear, a winter suit, and quilting.

At temperatures below 0°C, rubber boots must be worn with wool socks or footwear, and rubber gloves must be worn over wool. To dissipate heat in summer and at temperatures above +15°C, it is recommended that a wet cotton coverall be worn over the protective clothing. The coverall is periodically wetted as the water evaporates. If there is only radioactive contamination, only a radiation-protective coverall should be used to protect from fallout, without [additional] wearing special protective clothing.

In addition, time periods dependent on ambient temperatures have been designated for remaining in the protective isolating [leak-tight] clothing (Table 15). The indicated periods of time are given for working in protective clothing in direct sunlight and doing work requiring average physical effort. Trained healthy people working in cloudy weather may increase these periods of time one and a half times.

4.2.3 Improvised Skin Protection Devices

In addition to the special skin protection devices described above, improvised devices may be used to protect the skin from radioactive dust and biological media. These devices include ordinary clothing and footwear. Ordinary coverings and coats made of polyvinyl chloride or rubberized fabric, an overcoat made of heavy material, coarse cloth, or leather give very good protection from radioactive dust and biological media; they can also offer protection from TM in droplet form for a period of 5 to 10 min; quilted cotton clothing protects much longer.

Commercial and domestic rubber boots are used to protect the feet, as well as rubber overshoes, galoshes, felt boots used with galoshes, and footwear made of leather and artificial leather used with galoshes. When leaving the contaminated area, ordinary footwear may be wrapped with several layers of thick paper, burlap, or paper bags.

To protect the hands, rubber or leather gloves and canvas mittens can be used.

When using ordinary clothing for protection, for a high degree of airtight sealing it is necessary to close all buttoned openings and sleeve cuffs, tie the trousers with a strap, and turn up the collar and tie it with a scarf. For better airtight sealing of a zipper-closed trouser fly, it is necessary to prepare an apron inside the jacket which is rectangular in shape, with dimensions of 80 × 25 cm and with ties on the corners of the upper end to fasten it around the neck. At the opening of the upper end of the apron sew on a collar with a width of 4.5 to 5 cm, its length equal to the neck circumference.

Under the fly and trousers hook, sew on a flap. The length of each flap must be 3 to 4 cm longer than the zipper fly, and the width must make it possible to slip on the trousers with sewn-on flap.

To protect the neck and parts of the head not covered by a mask, it is necessary to sew on a hood.

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Fig. 47. Improvised means of skin protection: (*a*) Cotton jumpsuit; (*b*) overcoat.

Small children must be carried out of a contaminated area wrapped in cotton, wool, or flannel blankets. Women should wear trousers.

For more reliable skin protection, a simplified protective filtering set, with special impregnation, may be used to assure protection from TM vapors. The outfit may consist of a ski, worker, or school suit, an ordinary man's suit, or a standard jacket (jacket and trousers), gloves (rubber, leather, or impregnated wool or cotton), commercial or homemade rubber boots and rubber overshoes (galoshes) with impregnated stockings, felt boots with galoshes, leather footwear, and imitation leather galoshes (Fig. 47).

The clothes selected for impregnation must completely (in an airtight manner) enclose the body. The most available means for impregnating clothes in the home is solutions of synthetic detergents OP-7 or OP-10, used for washing, or soap-oil emulsions. To obtain the 2.5 liters of solution required to impregnate one outfit, take 0.5 liter of detergent OP-7 or OP-10 and 2 liters of water heated to 40 to 50°C and then carefully mix together for 3 to 5 min until a homogeneous bright-yellow solution is obtained.

When preparing 2.5 liters of a soap-oil emulsion, put 250 to 300 g of pulverized household soap or soap shavings in 2 liters of hot water (60 to 70°C). When the soap is completely dissolved, add 0.5 liter of mineral oil (eastor, transformer, machine, ete.) or vegetable oil (sunflower, cotton-seed) into the hot solution, mix for 5 to 7 min, and reheat to 60 to 70°C while eontinuing to mix, until a homogeneous soap-oil emulsion is obtained.

The solution must be prepared in an enamel or aluminum vessel in which the protective outfit ean also be impregnated: suit, hood, socks, gloves, and apron. First impregnate the suit and then the other parts of the outfit, because it is neeessary to achieve a completely uniform impregnation, especially of the suit. After impregnating the entire set, squeeze out excess liquid and dry in air. The elothes must not be ironed with a hot iron.

The clothes impregnated with the indieated solution do not have an odor; the solution does not irritate the skin and is easy to launder out. Impregnation does not harm the clothes and simplifies later degassing and decontamination.

The simplified proteetive set is put on over underwear or summer clothes. The coat (or jaeket) with the apron is tueked into the trousers, and the cuffs of the jaeket sleeves are tied with straps or in the protective leggings and gloves. The protective stockings (impregnated) are put on o[illegible] (nonimpregnated) stockings, and footwear i[illegible]

A quilte[illegible] ing over underwear, impregnated with the [illegible] described above. To make the quilted jaeket airtight, sew a thick fabric breast covering [gas flap], 22 to 25 cm wide, to the left part of the inside of the jaeket at a distanee of 10 cm from the edge throughout its whole length from the neck all the way to the bottom. The right side of the flap should be fastened to the right side of the quilted jacket on the inside by means of buttons or fasteners, attached 12 to 15 em from the edge. Buttons or hooks should be sewn on the lower front part of the quilted jacket, and straps should be sewn on the sleeves to enable them to be drawn tight.

5. Protective Civil Defense Construction

5.1 DESIGNATION AND CLASSIFICATION OF PROTECTIVE CONSTRUCTION

One of the methods for protecting the population from weapons of mass destruction is to shield it in shelters. Civil defense shelters to protect the working shifts, work crews, and population include:

1. blast shelters with industrially manufactured filtering equipment;
2. blast shelters with rugged filtering equipment;
3. fallout shelters prepared in peacetime (special structures or modified farm buildings);
4. fallout shelters constructed in wartime of available materials.

Blast shelters are airtight protective buildings which shield their occupants from the damaging effects of a nuclear blast, as well as from toxic materials and biological media. In shelters located in zones of possible conflagrations or in a possible secondary chemical focal area (created as a result of the destruction of industrial targets), shelter is provided from high temperatures, contamination from burning products, and industrial toxins.

Shelters are classified according to their protective properties, capacity, location, and filtering equipment. They are classified into five groups according to the degree of protection they offer from the blast wave of a nuclear burst.

1. According to capacity (number of people protected) the shelters are [designated as] small, up to 150 people; medium, from 150 to 450 people; and large, more than 450 people.

2. According to location, the shelters may be permanent or temporary. Permanent shelters include shelters in the basements of buildings, and temporary shelters include those outside of buildings.

3. According to the [desired] efficiency of the filtration system, the shelter may be equipped with industrial filtering equipment, with simplified filtering equipment, or with an air-supplied system (without filters).

4. Fallout shelters protect their occupants from contamination by radioactive substances and from radiation in zones where fallout is prevalent.

5. According to the degree of protection from radiation (degree of gamma-radiation attenuation) fallout shelters are classified into three groups.

In a zone of possible slight destruction, these shelters assure protection from collapsed buildings as well.

5.2 SHELTERS: DESIGN AND EQUIPMENT

5.2.1 Shelter Requirements

Shelters intended to protect workers and employees at national economic sites, and also the general population and those responsible for the essential services of a city, must offer protection from all the damaging factors of a nuclear burst, from toxic and radioactive substances, and from biological media. The safety construction of the shelters, that is, the [strength of the] walls and ceiling, must be designed to withstand the effects of the shock wave of a nuclear surface burst. The design features of shelters which protect against the shock wave are determined in each specific case, with regard to the safety characteristics of the basic stress-bearing construction of the building, the appropriate equipment, and the location with respect to the center of the city.

Blast shelters must ensure protection from initial nuclear radiation and radioactive contamination. The protective characteristics of shelters in each case depend on the construction and density of the materials, as well as the compactness of the soil.

The shelter entrance must have the same degree of protection as the main structure. An emergency exit must be built to evacuate people from the shelter if the entrance is destroyed or if rubble falls in front of it.

The shelter [ceiling] height must not be less than 2.2 m. The dimensions of the shelter and its capacity are determined as a function of the climate in which the shelter is built. For temperate zones in the Soviet Union, the minimum standard is 0.5 m^2 [5 ft^2] of floor area over and above equipment space and 1.5 m^3 [53 ft^3] of air space per person.

Blast shelters must be equipped with ventilation devices, sanitary facilities, and appliances, as well as means for purifying the air of toxic and radioactive substances and biological aerosols. Blast shelters located at sites of possible conflagrations must be provided with inlet air-cooling devices and means to protect people in the shelter from dangerous concentrations of carbon monoxide.

Shelters must be constructed in places which are not threatened by flooding, torrential rains, or emergency flooding [e.g., broken water main]. There must be no large water reservoirs or water or sewer mains near the shelter, which if destroyed or damaged might threaten the people in the shelter with drowning. Sewer pipes near the shelter must be enclosed in a metal duct or in a reinforced concrete duct, firmly embedded in the ceiling and in the floor.

Placing the shelter in industrial buildings where technical equipment causes vibrations which may disturb the airtight sealing of the shelter is not recommended. There must be no heavy equipment on the floors above the shelter.

Shelter approaches in buildings must be free of decoration and flammable materials or materials likely to smoulder.

In planning the construction of shelters it is necessary to provide for their dual use: in peacetime, to store spare parts and other equipment for industries and some technological processes; in wartime, to shelter and protect people from the effects of weapons of mass destruction.

When such shelters are constructed, in addition to the protection requirement (reinforced safety design, protected entrances, air-intake ducts, filtering system, etc.), it is also necessary to take into account the special features connected with working in these premises in peacetime.

Shelters may be combined with buildings of the following types:

1. industrial buildings having technological processes which do not endanger human beings;
2. testing stations;
3. buildings for electricians and repair crews;
4. movie theaters, garages, dining rooms, restaurants, cafes, and other premises of various economic and cultural types.

The use of dual-purpose shelters in peacetime must not interfere with their protective characteristics. The conversion of such shelters to wartime operation must be possible within a minimum period of time – no longer than 12 hr.

If the shelters were constructed without a specific peacetime purpose, then they may be used, for example, for patriotic displays, exhibitions, and exhibits of craftsmanship and the like, with consideration given to maintaining the protective construction and special equipment and ensuring the rapid preparation of the facilities to receive occupants.

5.2.2 Shelter Arrangement

As a rule, blast shelters must have areas for occupants, a filter-ventilation chamber, a medical room, lavatories, food storerooms, and vestibules (Fig. 48). In small-capacity shelters, mentioned earlier (Fig. 49), air filtration equipment and food are located in the same area as the occupants, in the absence of special facilities. A medical room may not be set up in such shelters. In large-capacity shelters there may even be facilities to install a diesel generator and a well with a pump.

The walls of the shelter may be made of stone (bricks, concrete blocks), butoconcrete, and monolithic or modular reinforced concrete. The exteriors of underground walls are waterproofed. Blast shelter ceilings are not plastered, but are finished with a cement solution and painted.

The shelter floors are placed on a concrete foundation or, when there is a uniform base, without any foundation. The type of finished floor is selected in keeping with the shelter's peacetime use. Moisture-resistant floors are installed in the lavatory units.

Blast shelters have entrances and emergency exits. The number of entrances is determined by calculating one entrance of 80 × 180 cm per 200 persons or [an entrance of] 120 × 200 cm per 300 persons.

Protection from radioactive and toxic substances, biological media, and the combustion products of fires which might penetrate the shelter through the entrance is ensured by vestibules and antechambers constructed at the entrances. In the vestibule there are airtight blast doors and airtight doors. The doors have rubber strips and wedge seals, assuring a tight fit between the door edge and frame. In shelters with a capacity of 600 or more, an airlock is provided for one of the entrances, which ensures that the protective characteristics of the shelter are maintained when people are admitted after the other entrances have been closed. Protective airtight doors are installed in the airlock openings.

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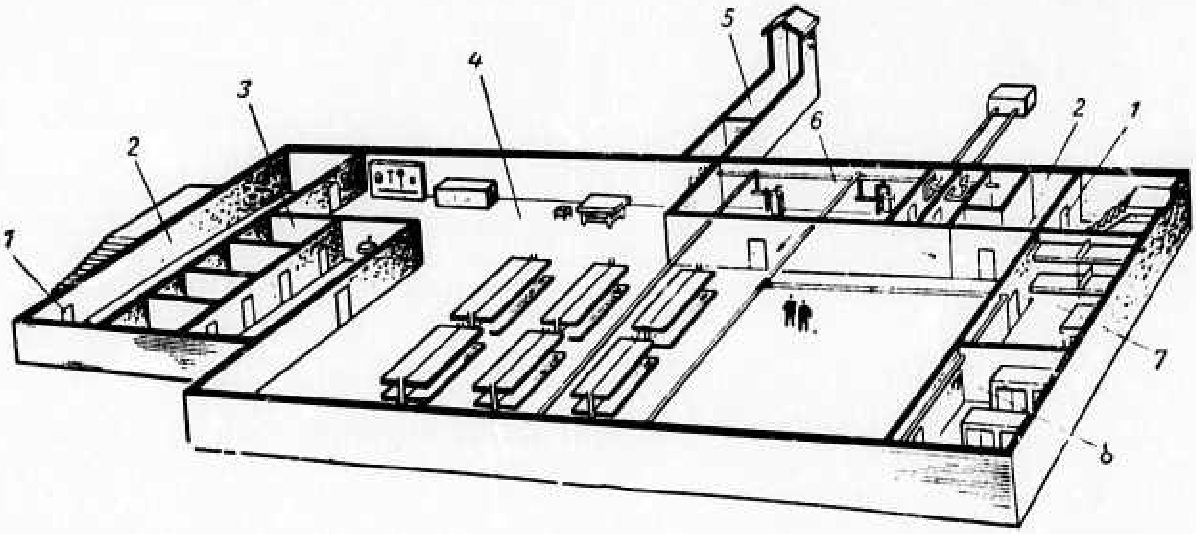

Fig. 48. Diagram of a shelter for long-term protection from the damaging effects of weapons of mass destruction: (1) protective airtight door; (2) air lock; (3) lavatories; (4) areas for shelter occupants; (5) tunnel and vent cap of the emergency exit; (6) filter-ventilation compartments; (7) medical room; (8) storeroom for food.

An emergency exit is set up in the form of an underground tunnel with dimensions of 90 × 100 cm, with an exit into an open area through a vertical shaft, covered with a vent cap. Side openings are placed in the upper part of the vent cap, with dimensions of not less than 60 × 80 cm; [these openings are] covered with grates and open outside the shaft. The vent cap of the emergency exit must be removed from surrounding buildings at a distance not less than half the height of the building plus 3 m ($L = 0.5\ H_{buil} + 3$ m). A detached shelter need not have an emergency exit if it is located in an open area. The height of the vent cap must be such that the upper opening is located not lower than 1.2 m [from ground level], or not lower than the level to which the vent cap might be obstructed by rubble.

The distance of a blast shelter from working sites or from residences must not be more than 300 to 400 m.

5.2.3 Interior Shelter Equipment

The interior equipment of blast shelters and premises adapted as shelters consists of an air-supply system, sewer lines, electrical power and heating supply, and protection for the air intake and exhaust parts.

Bunks or level benches are set up for convenience of arranging people in compartments of the shelter (railway car type): the lower one for sitting, with dimensions of 0.45 × 0.45 m per person; the upper one for lying down, with dimensions of 0.65 × 1.8 m per person.

The shelter is equipped with communication and warning equipment (telephone and loudspeaker, connected to outside telephones and to a radio broadcasting system). In case the external telephone and radio network is knocked out of operation, it is desirable to have a radio station in the shelter that can operate with an underground antenna for receiving [messages] from the CD staff office (regional).

The interior equipment ensures the collective protection of those in the shelter and helps to maintain healthful conditions. Interior equipment contributes to a healthful shelter environment. The most important factors affecting the sanitary-hygenic conditions in shelters are temperature, humidity, and the composition of the air. It is known that placing a large number of people in an airtight enclosure causes an abrupt change of the atmospheric conditions which is manifest in increased temperatures, increased humidity, increased carbon dioxide content, reduced oxygen availability, and an accumulation of fetid materials. Such changes may adversely affect personal health and lead to more serious consequences for the people in the shelter.

For example, with ambient shelter temperatures of 30 to 32°C [86 to 89°F] and 90% relative humidity, people suddenly begin to have unpleasant sensations – weakness, suffocation, restlessness – which have an adverse effect on their physical and psychological condition. An increase in temperature and relative

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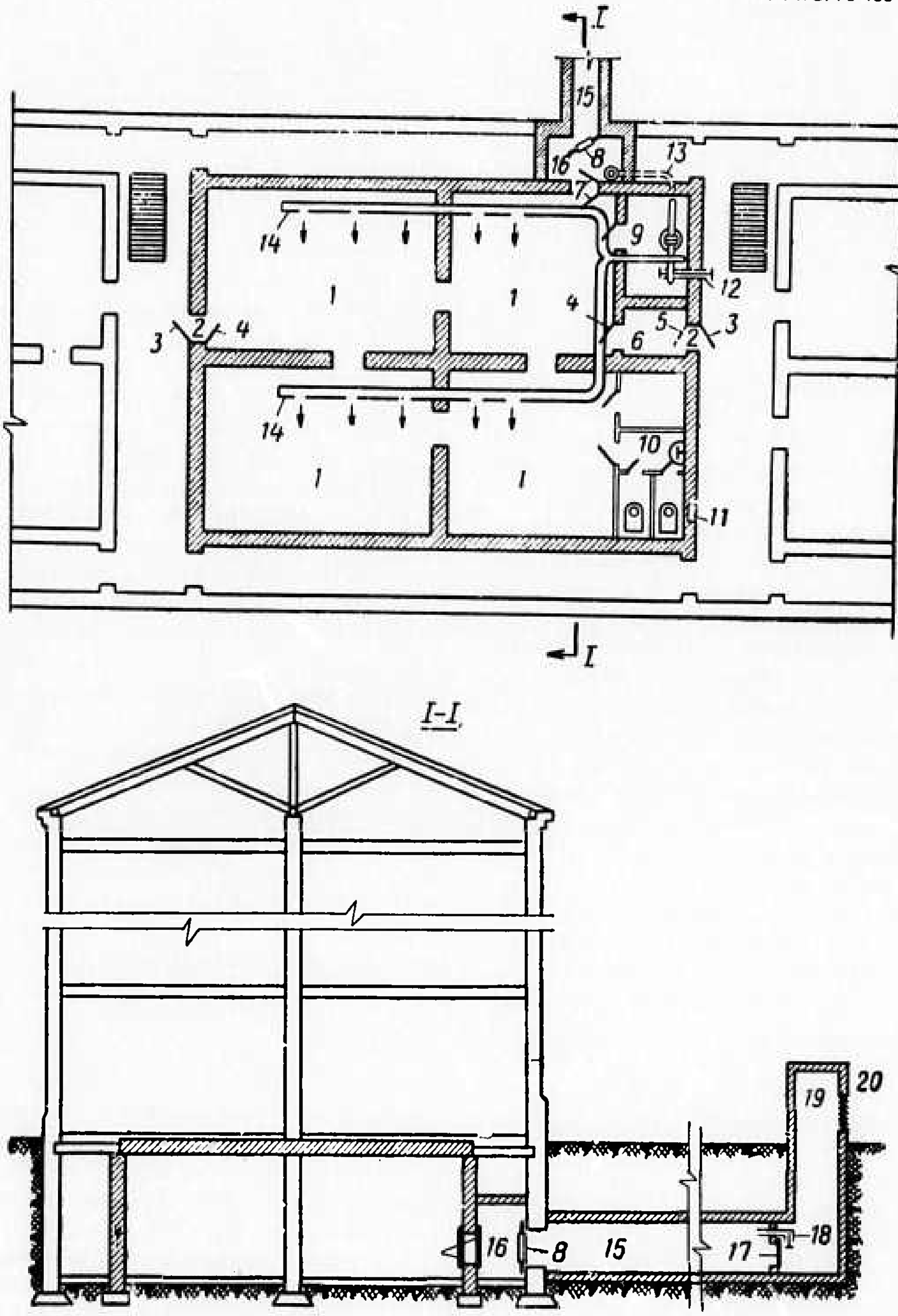

Fig. 49. Shelter in the center of a building basement: (1) compartments; (2) exits; (3) and (4) protective airtight doors; (5) louvered wooden door; (6) vestibule; (7) protective airtight shutters; (8) shutter with dust filter; (9) filter-ventilation chamber; (10) lavatories; (11) exhaust duct; (12) sealing safety valve; (13) basic air intake duct; (14) pressurized pipes. (15) emergency exit; (16) adjoining chamber; (17) airtight safety shutter in emergency exit; (18) floating cutoff valve; (19) vent cap of the emergency exit; (20) wooden louver grating.

humidity in the air occurs in shelters due to the release of heat and moisture from people's bodies.

Under normal atmospheric conditions the basal heat loss of an adult is 75 kcal/hr [300 Btu/hr]. Under conditions in a shelter of the size on which our calculations are based, 100 kcal/hr [400 Btu/hr] of heat is lost to the air.

The total amount of water given off depends largely on the heat-exchange conditions between the human body and the ambient [shelter] air. For practical calculations to determine the amount of water given off we may use the formula [see note*]:

$$d = 7(t_B - 15),$$

where d is the amount of water given off by one human being (g/hr) and t_B is the temperature of the ambient air (°C).

In the process of respiration, a person inhales oxygen and exhales a certain quantity of carbon dioxide (about 4% of the volume of inhaled air). In a state of rest and under normal meteorological conditions, a person requires 14.2 liters of oxygen per hour and exhales 11.8 liters of carbon dioxide. When inside the shelter, an increase in pulmonary ventilation is observed in humans, and the oxygen requirement increases up to 24 liters/hr, while the amount of carbon dioxide expired increases to 20 liters/hr. Because of this, the change in gaseous composition and heat-humidity conditions of the air in shelters is rather marked, and dealing with these changes presents great difficulty.

In unventilated shelters, the decisive parameter determining the condition of the occupants during their confinement in the shelter is the composition of the shelter air, since this becomes limiting before the heat-humidity conditions. If we assume that the shelter's volume per person is 1.3 to 1.5 m^3 [46 to 53 ft^3], the carbon dioxide concentration after 2 to 2.5 hr increases by 3.4%. Further confinement of the occupants to the unventilated shelter may result in serious consequences.

The time of increase in the carbon dioxide concentration up to critical values is determined according to the formula

$$t = \frac{C_{dop} V}{100B},$$

where C_{dop} is the limit concentration of carbon dioxide (%), V is the volume of the premises for one human being (m^3), and B is the amount of carbon dioxide expired by one adult (liters/hr).

In ventilated shelters the greatest difficulty is dealing with excess heat and humidity. When 2 m^3/hr [1.1 cfm] of ambient air is supplied per person, the concentration of carbon dioxide in the shelter does not exceed 1.5%. However, when air is admitted for 10 to 12 hr, the temperature in the shelter increases to 29 to 30°C [84 to 86°F], and conditions for those in the shelter deteriorate. Thus, the normal air supply must be increased 2 to 3 times [see note*] for extended confinement to the shelter.

Air supply in the shelters. As a rule, supply of ambient air to shelters must be ensured by two systems: by a clean ventilation system (primary system) and by a filter-ventilation system (secondary system). In shelters located in possible fire zones, it is also necessary to provide for a partial-insulation system, along with cleaning of the ambient air from combustion products during fires, and cooling of the air and regeneration of the internal air (tertiary system). The clean ventilation system purifies the ambient air of radioactive dusts, and the filter-ventilation system removes radioactive dust [and also] toxic materials and bacteriological agents. Ventilation system changeover is achieved by airtight valves and by activating existing fans.

The air-supply system consists of air-intake installations, dust filters, absorption filters, a heat-capacity filter, fans, air-expansion chambers, and air-regulation facilities. In the air-supply system of shelters located in possible fire zones, there is also a carbon monoxide filter and means for regenerating the air (Fig. 50).

A dust filter, in particular a screen filter, of different design is used to free ambient air of radioactive dust. The screen dust filter (Fig. 51) consists of a metal screen pack assembled in a unit with dimensions 510 × 510 × 80 mm. The screens are impregnated with machine oil. When the air passes through the filter, airborne dust adheres to the oily layer on the screen. The capacity of one filter pack is 1000 to 1100 m^3/hr with an aerodynamic resistance of 3 to 8 mm. Dust filters are located in special places (chambers), separated from the shelter proper by a main wall to protect the occupants from exposure to radioactive substances which accumulate on the filter.

[*This formula is realistic; for 24 hr at 90°F, it indicates 3.1 quarts of water per person as the loss by sweating and respiratory processes.]

[*This guidance is not consistent with the more realistic requirements stated in Table 16, which specify 20 m^3/hr (10.6 cfm) per person of outdoor air at 30°C (86°F).]

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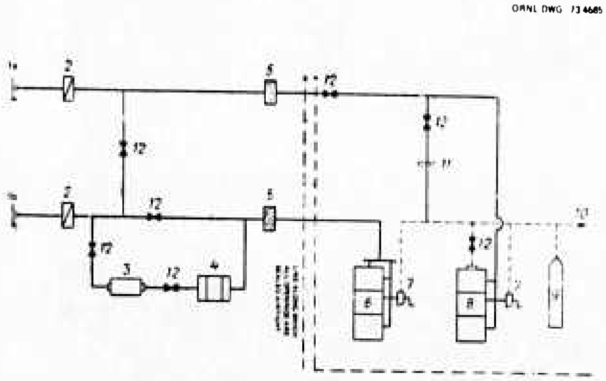

Fig. 50. Schematic diagram of a shelter supply system with industrial equipment (variant): (*1a*) air intake on the filter-ventilation system; (*1b*) air intake on the clean ventilation system; (2) antiexplosion mechanism (gravel blast attenuator); (3) carbon monoxide filter; (4) heat-protective filter; (5) dust filter; (6) filter-ventilation unit; (7) electro-manual ventilator fan; (8) regenerating unit; (9) oxygen bottle; (10) air-separation network; (11) ROV electric blower; (12) airtight valves.

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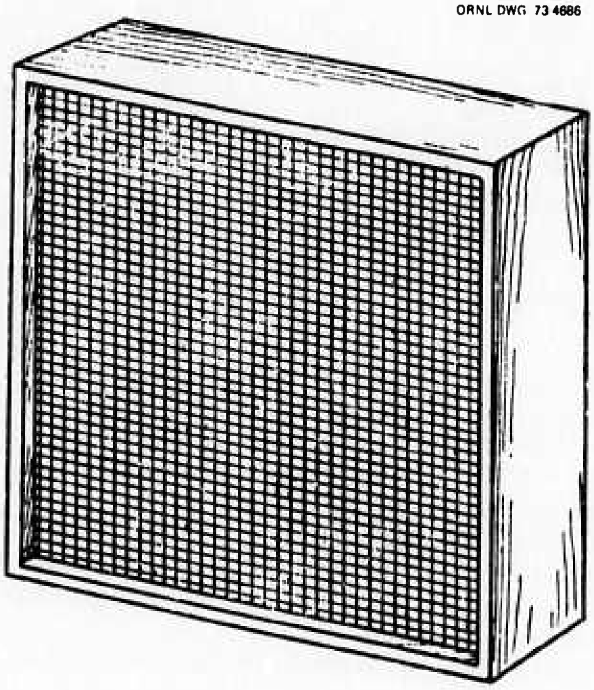

Fig. 51. Screen dust filter.

Freeing the ambient air of toxic materials and biological media is accomplished by filter absorbers of types FP-100, FP-100Y, and FP-200-59.

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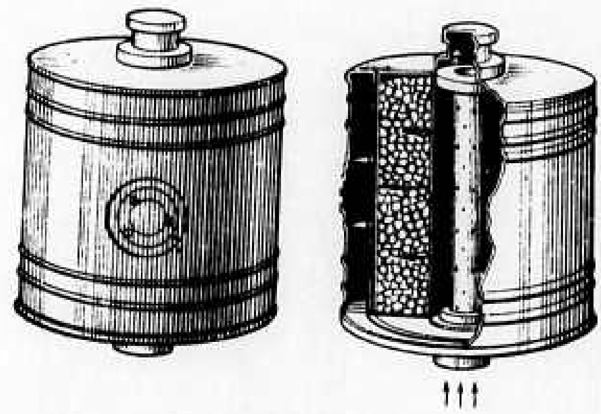

Fig. 52. Absorption filter.

The absorption filter (Fig. 52) consists of a cylinder with two central (top and bottom) openings and one side opening. It operates on the same principle as the filter-type gas mask. Ambient air enters the filter through one of the central openings, passes through a cardboard filter and a layer of carbon adsorbent, where it is freed of toxic materials and biological media, and then passes through the side opening. The absorption filters are stacked in columns, 2 to 3 in each [column]. Stacking more than three filters is not permitted since this greatly increases the resistance of the filter collectors. If necessary, feeding more air into the absorption filter stacks will require the use of a battery.

Electric blowers are used to force ambient air into the shelters, and, in large-capacity shelters (more than 450 people) with a protected independent power source, centrifugal fans with an electric drive are used. As a rule, filter-ventilation unit FVA-49 (Fig. 53) is used in small- and medium-capacity shelters. The FVA unit includes an electrically powered blower ERV-49, an absorption filter, a double-acting sealing valve, a flowmeter, and connecting and mounting components.

To cool the inlet air in the event of fires, it is possible to use filters of gravel or other heat-absorbent materials. The gravel is distributed in a special chamber with brick or reinforced concrete walls, on a metal grating. When the shelter is located in a possible isolated fire zone, the volume of the gravel must be 2 m^3 [70 ft^3] per 300 m^3/hr [165 cfm] of inlet air and 100 m^3/hr [55 cfm] in possible fire storm or conflagration zones. The thickness of the filter bed should be 0.8 to 1 m.

To calculate the heat capacity of the filter, we use the formula

$$H = 0.25 + 0.005\ V/S\ ,$$

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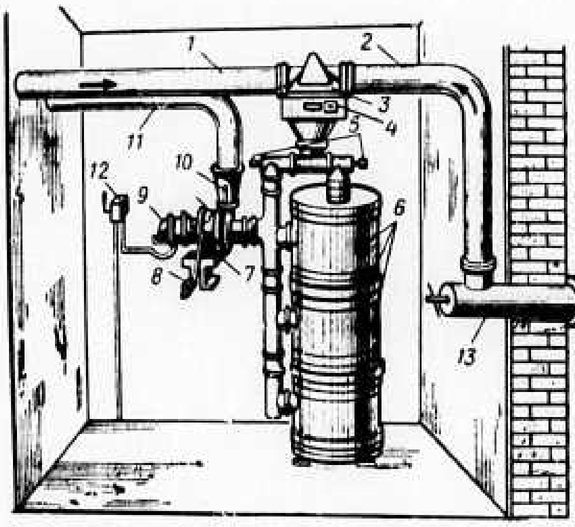

Fig. 53. Filter-ventilation unit (FVA-49): (1) basic air intake; (2) emergency air intake; (3) handle of butterfly valve; (4) dust-proof oil filter; (5) changeover rod of the double-sealing valve; (6) filter absorber; (7) electro-manual blower; (8) blower shaft; (9) electric motor; (10) air-separation system; (11) ROV electric blower duct; (12) sealing valve.

where H is the height of the filter bed (m), V is the amount of air supplied to the shelter (according to a standard of 2 m^3/hr [1.1 cfm] per person), S is the surface of the filter bed (m^2), and V/S is the ratio determining the air flow rate, which must not be greater than 400 m/hr.

When group fires spread in cities, the air is contaminated with carbon monoxide, which is very toxic. When the carbon monoxide concentration is 0.45 mg/liter [0.04%, or 400 ppm], people suffer headaches and nausea in 1 to 2 hr, and concentrations of 3.6 mg/liter [0.3%] are fatal in 30 min. In group fire zones the carbon monoxide content in the air may be from 0.4 to 5.4%; at the same time, the oxygen content of the air may decrease to 6% and the carbon dioxide content may increase to 3 to 16%. For this reason the air supply system includes carbon monoxide filters. It is possible to use industrial emission filters FMSH and hopcalite cartridges of the FK-G type as carbon monoxide filters. In these, carbon monoxide is oxidized with atmospheric oxygen to carbon dioxide. In this case, hopcalite is a catalyst.

The low oxygen content and high carbon dioxide content in the atmosphere of fire zones disqualify ambient [outdoor] air for air-supply use, even in shelters equipped to cool and clean the inlet air of carbon monoxide. In this case, it is necessary to convert the shelter to completely self-contained operation with regeneration of its atmosphere. Air may be regenerated in shelters with the aid of a convection-type regeneration unit (CTRU), which uses sodium or potassium peroxide compounds. These assure simultaneous absorption of the carbon dioxide and release of oxygen. One kilogram of a potassium peroxide compound can release as much as 250 liters of oxygen and absorb 150 liters of carbon dioxide.

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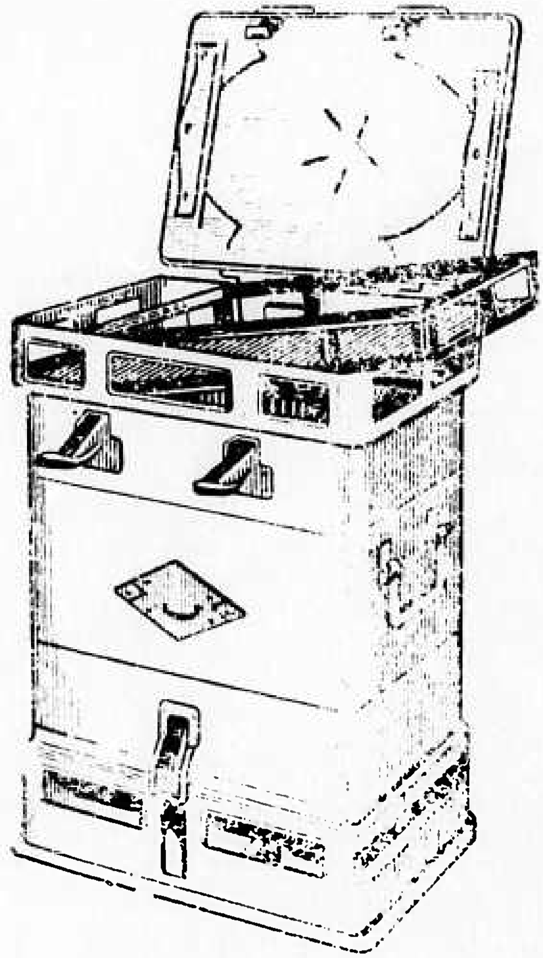

Fig. 54. CTRU regenerating unit.

The CTRU unit (Fig. 54) consists of a metal housing in which cartridges are inserted with the peroxide compounds. In the lower part of the housing, there is an opening for the intake of air, and in the upper part there is an outlet for the regenerated air. The top of the housing is closed with a cover. This unit does not require the use of a forced draft, since air is drawn through the unit by thermal pressure (convection currents).

The convection type regenerating unit is installed in the same area as the shelter occupants. The number of units is calculated as a function of regeneration time, number of occupants, and power of the unit.

To prevent penetration of ambient air through leaks in the shelter, it is necessary to maintain an air overpressure equal to 1.5 to 2 mm H_2O. This is achieved by supplying air through the filter-ventilation system at a rate of one-third the volume of the premises [entire shelter] per hour. Thus, in shelters located in possible mass fire zones, it is necessary to use a special air-supply system. This system is intended to supply the minimum amount of ambient air required to maintain the overpressure; the air is purified from carbon monoxide, and regeneration equipment is also used in order to maintain the gas composition of the atmosphere within tolerable limits. As a rule, air fed into the shelter through the filter system enters through two air-intake ducts, of which one is primary and the other on standby.

To protect the air-supply system and the filter-ventilation equipment from damage and to prevent the blast wave from penetrating the ventilating ducts, antiexplosion devices have been designed, consisting of metal deflectors (Fig. 55*a*), reinforced protective units (Fig. 55*b*), floating cutoff valve KOP, etc.

Depleted air is removed from the shelter through exhaust ducts in which sealing and regulating valves as well as antiblast mechanisms have been installed. Exhaust fans are set up in large-capacity shelters. The exhaust ducts in the shelter are closed with overpressure valves (OPV) (Fig. 56). This valve in the exhaust duct consists of a metal disk with a rubber packing connected to the metal housing by a pin and a hinge. The disk is pressed to the valve seat by the action of the blast wave, closing the orifice through which the depleted air is removed.

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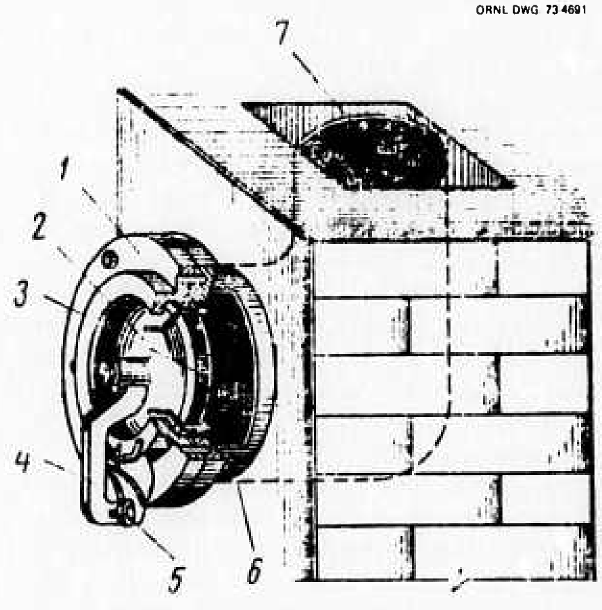

Fig. 56. Overpressure valve (diagram of the unit at inlet of bathroom exhaust duct; the arrows show the direction in which the air is moving from the shelter): (1) valve housing; (2) disk; (3) rubber lining; (4) lever connecting the disk to the valve housing; (5) counterweight system for regulating the disk position; (6) metal pipe; (7) exhaust duct.

The following modes of operation are conditionally provided for the filter-ventilation unit: in the absence of contamination, the clean ventilation mode with an air supply of 7 to 20 m^3/hr [4.1 to 10.6 cfm] per person (Table 16); in the presence of atmospheric contamination, the filter-ventilation mode with an air supply of 2 m^3/hr [1.1 cfm] per person; at the moment of a nuclear burst, the self-contained mode,

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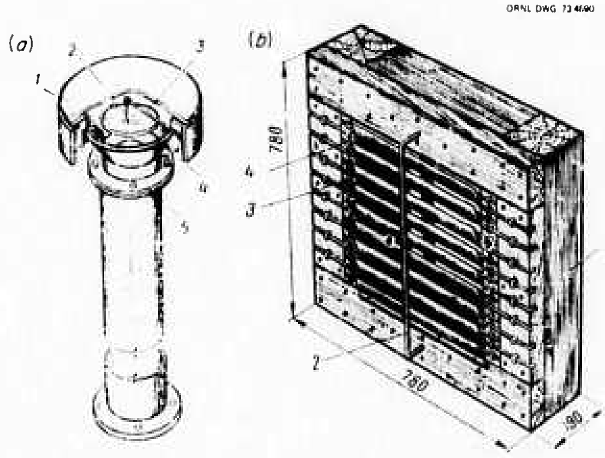

Fig. 55. Antiexplosion mechanism: (*a*) metal deflector – (1) cover; (2) spring; (3) support for flap; (4) flap; (5) housing: (*b*) reinforced protective units – (1) frame; (2) bracket; (3) blade; (4) crosspiece.

Table 16

Ambient air temperature (°C) [°F]	Air-supply standards for the clean ventilation system per person (m^3/hr) [cfm]
20 [68]	7 [4.1]
20–25 [68–77]	10 [5.8]
25–30 [77–86]	14 [8.2]
30 [86]	20 [10.6]

whereby the filter-ventilation system is turned off for 1 hr and the sealing valves are closed, and [as a result] the system is completely self-contained.

The shelter is supplied with electricity from the municipal (plant) power plant. The basic consumers of electrical energy in the shelters are the lighting system and the electric-powered ventilating system. In addition some shelters require electrical energy for an artesian well pump. A diesel-generator may be placed in large-capacity shelters for emergency power. In shelters without an independent protected electrical power source, emergency lighting is provided by batteries or pocket flashlights, bicycle-powered generators, and the like. However, the blower assembly is worked with a manual drive mechanism.

Candles and kerosene lamps are used for illumination to a limited extent and only under good ventilation conditions. When calculating the air supply, it is necessary to take into account the character of the illumination, since the air will be highly contaminated with combustion products when candles and kerosene lamps are used.

Air is used to ventilate the generator system and [also] to cool motors; the air is drawn from the shelter proper. In the case of an air deficit, a supply of ambient [outdoor] air into the generator system is provided, after it has been cleansed of radioactive dust.

Water supply and sewer system. As a rule, a shelter's water supply and sewage disposal systems are based on the existing municipal or installation water supply and sewer systems. However, in view of the probability of these systems being destroyed by a nuclear burst, an emergency water supply must be provided in the shelter, as well as sewage water tanks that operate independently of the outside sewer system. To maintain the emergency water supply, use is made of flow-through pressure reservoirs or pressureless containers equipped with removable covers, float valves, and water-level gauges.

The minimum water supply for drinking and for washing hands in the shelter is 3.5 to 4 liters per person per 24-hr period; 16 to 20 liters are required for normal operation of the sewer system. Consequently, in a shelter with a capacity of 300 people, the daily water supply must be about 7 m^3, for which 1 m^3 [270 gallons] is for drinking and 6 m^3 [1620 gallons] is for operating the sewer system.

Emergency water supply facilities are established in the shelter. The running-water tank is usually located under the ceiling in sanitary units and in pressureless reservoirs – in special compartments. To purify the water in the shelter, there must be a supply of chlorinated lime or DTS-GK. A mixture of 8 to 10 g of chlorinated lime or 4 to 5 g of DTS-GK is required to chlorinate 1 m^3 of water.

Gate valves are installed in the water supply pipes and other systems in the shelter to prevent damage from [damage to] outside systems. The shelters are equipped with flush drains which admit water to the existing sewer system to remove stagnant and fecal water. In the detached shelters, pumping stations have been provided to pump sewage water into the sewer system. In case the outside water supply system and the sewer system have [both] been damaged, an emergency sewage unit is installed inside the shelter, consisting of vessels for collecting sewage (temporary waste holdup containers).

Heating. Central heating is provided to blast shelters from the heating system of the building (district heating plant). Dampers are installed on horizontal pipelines to regulate and turn off the heat inside the shelter. The pipes of the engineering network inside the shelter are color-keyed:

White, air-intake pipes of the cleaning and ventilating system;

Yellow, air-intake pipes of the filter-ventilating system;

Red, ventilation pipes in case of fire (leading to the heat capacity filter);

Black, electrical conduits;

Green, water pipes;

Brown, heating ducts.

On air-intake and water pipes and heating ducts, arrows on the inlet indicate the flow direction of the air or water. In addition to the interior equipment which we have considered, a blast shelter is provided with various fireproof, sanitary, and other equipment, as indicated in the appendix.

5.2.4 Adapting a Basement as a Blast Shelter

A basement may be remodeled as a shelter. For this [purpose] it is necessary to do the following: to reinforce the ceiling and interior walls, coming out on the stairwell and in the adjacent nonmodifiable premises (reinforcement is not provided for exterior basement walls); to construct an entrance of 60 × 160 cm using the existing entrance from the stairwell; to construct two simple emergency exits (manholes) and adapt them for air flow-through; to seal unnecessary openings and communication apertures; to construct a sanitary unit with a cesspool, a floor, plank bunks, and sand filters.

As joint reinforcement of the ceiling and the interior basement walls, longitudinal log frames are erected, fastened transversely by horizontal clamps made of strips 4 to 5 cm thick and floor boards, and nailed to a horizontal frame, while the walls are reinforced with supplementary timber supports set up along the front of the longitudinal frame. Boards are laid behind the support and are nailed to the vertical clamps.

Metal construction is reinforced by increasing its lateral cross section and welding on metal supports, that is, I beams, channel irons, sheet metal, etc. Reinforced concrete construction is strengthened on one side by cast monolithic concrete with supplementary reinforcement.

The bearing capacity of the safety construction is increased by installing additional interstitial supports in an arch. Decreasing the [span of an] arch reinforces the construction and increases its bearing capacity. For example, when the span of an arch is halved, its bearing capacity is quadrupled (Figs. 57 and 58).

Protection from the effects of initial nuclear radiation and high temperature may be obtained by covering the surface of the ceiling with boards 3 to 5 cm thick,

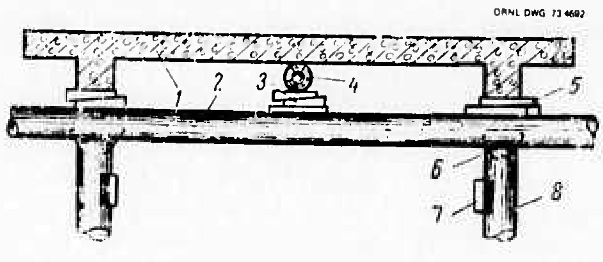

Fig. 57. Reinforcing ribbed ceilings: (1) plate; (2) lining; (3) beam; (4) girder; (5) shims; (6) brackets; (7) interlock; (8) support [column].

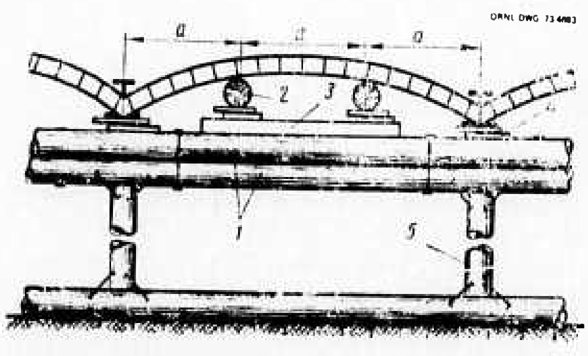

Fig. 58. Reinforcing a brick arched ceiling: (1) double girder; (2) beam; (3) lining; (4) shims; (5) support [column].

reinforcing the horizontal clamps, piling earth (slag) over the existing cellar roof, or stacking sand bags.

The entrance is equipped with a protective door of the BD type 60 X 160-0.6 and an airtight door GD-60 X 160-0.1 [both of] which are installed in the vestibule unit. The simplified emergency exits (manholes) are of wood-earth construction, using existing windows. Auxiliary manholes with vent caps are installed in multistory buildings.

The bathroom is equipped, according to plan, with one toilet per 50 to 75 people, with a cesspool and a discharge rate (reserve) of 4 liters per person. The bathroom flue is a wooden box [duct] with a vent cap having a protective baffle plate, covered with scrap materials. To collect the solid waste products, a refuse storage tank is installed with a capacity of 2 liters per person.

Chinks and fissures in the shelter construction are sealed with rags and a cement solution. Tiered plank bunks made of a board frame and panels are built in basement shelters.

The air-supply system in basements remodeled for blast shelters consists of sand (slag) filters and fans with bicycle-powered mechanisms, or bellows-bags, and also an ROV ventilation unit. The amount of forced air [required] for the filter-ventilation system is calculated from the air supply as not less than 2 m^3/hr [1.1 cfm] per person.

Air for the clean ventilation system is admitted into the shelter from the reserve manhole through the air intake in which a protective UZC unit is installed for protection against the blast wave (see Fig. 55*b*). To clean the air of radioactive dust, there is a screen dust filter. Openings of 30 X 30 cm are installed in the partitions of the shelter to enable the air to flow from one room to another.

Air is removed from the shelter through an exhaust duct, exhaust valves in the airtight doors, and the exhaust ducts in the lavatory. The lavatory ducts are protected by a vent cap with a protective device and an exhaust opening in the walls with UZS or OPV protective units.

In these shelters there must be a reserve supply of drinking water in tanks, 600 liters per 100 persons. Food for the occupants is stored in cans on shelves.

The amount of materials required to remodel a basement into a blast shelter with a capacity of 100 persons is listed in Appendix V.

5.2.5 Rugged Filter-Ventilation Equipment

Rugged FVO devices. To clean the inlet air of radioactive dust and toxic and biological materials,

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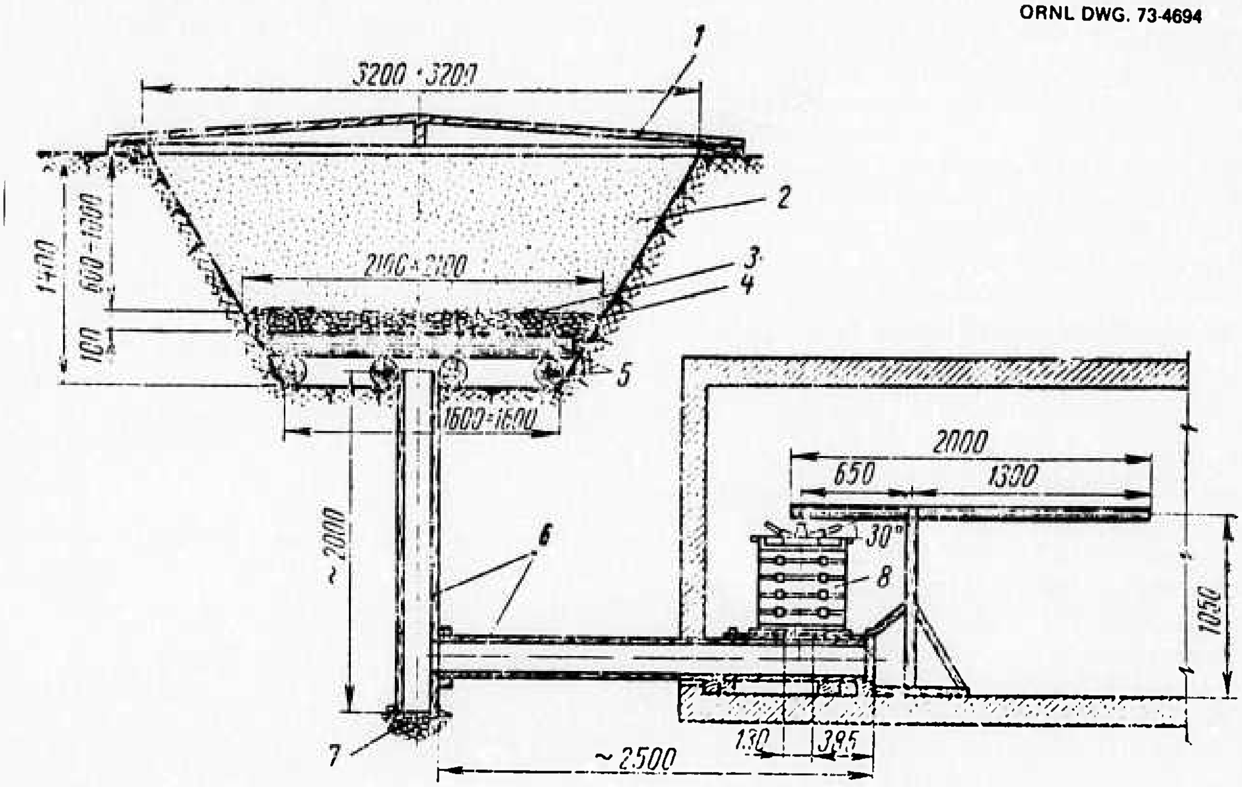

Fig. 59. Rugged filter-ventilation equipment: (1) cover for protecting the filter from atmospheric fallout; (2) coarse sand and coal slag; (3) fine gravel; (4) coarse gravel; (5) beam of 15 to 16 cm diameter; (6) duct; (7) drainage; (8) bellows.

rugged filter-ventilation equipment is used, including sand or slag filters and a bicycle-powered fan or bellows.

The filter is set in the excavation, the sloping sides of which are covered with a layer of waterproofing materials or with a 10-cm-thick layer of compacted clay. The filter walls must be constructed of brick or wood and carefully sealed airtight. The inner surfaces of the walls must have ribs projecting into the sand in order to prevent air leaks between the walls and the sand (Fig. 59).

A metal or a wooden grating, with a diameter of 15 to 16 cm, is laid on the bottom of the excavation. The grating is covered with a 10-cm-deep layer of gravel of 25 to 30 mm particle size and then a 5 to 6 cm layer of 5 to 10 mm particle size. A load of local filtering materials is placed on the gravel, for example, sand of 0.5 to 3 mm particle size, shell rocks of 0.5 to 1 mm particle size, and furnace slag of 0.05 to 5 mm particle size. The top of the filter bed is covered with a sloping roof to protect it from rain and snow. The depth of the sandy layer, which purifies the air of toxic materials and bacteriological media, must be not less than 1 m and of furnace slag or shell rocks not less than 0.75 m.

The cross-sectional area of the absorption filter is determined by the capacity of the shelter and the standard per capita air supply (depending on the ventilation system). The required cross-sectional area S of a bed is calculated according to the formula

$$S = \frac{nV}{W} \text{ m}^2 ,$$

where n is the number of people in the shelter, V is the standard air flow rate for one person (m^3/hr), and W is the air flow through 1 m^2 cross section of the bed per hour (m^3/hr).

For a sand absorption filter $W = 30$ $m^3/hr{\cdot}m^2$, and for an absorption filter of slag, shell rocks, or opoka, $W = 60$ $m^3/hr{\cdot}m^2$. Table 17 gives the minimum area of a bed for a simplified absorption filter for a standard air flow rate of 2 m^3/hr [1.1 cfm].

The proper operation of the rugged absorption filter devices is checked on the basis of the air flow resistance

Table 17

Shelter capacity (number of persons sheltered)	Absorption filter capacity (m^3/hr)	Absorbent surface of the absorption filter, depending on the filter material (m^3)		
		Opoka and shells	Coal slag	Sand
50	100	1.65	1.65	3.3
100	200	3.3	3.3	6.6
150	300	5.0	5.0	10.0
300	600	10.0	10.0	20.0

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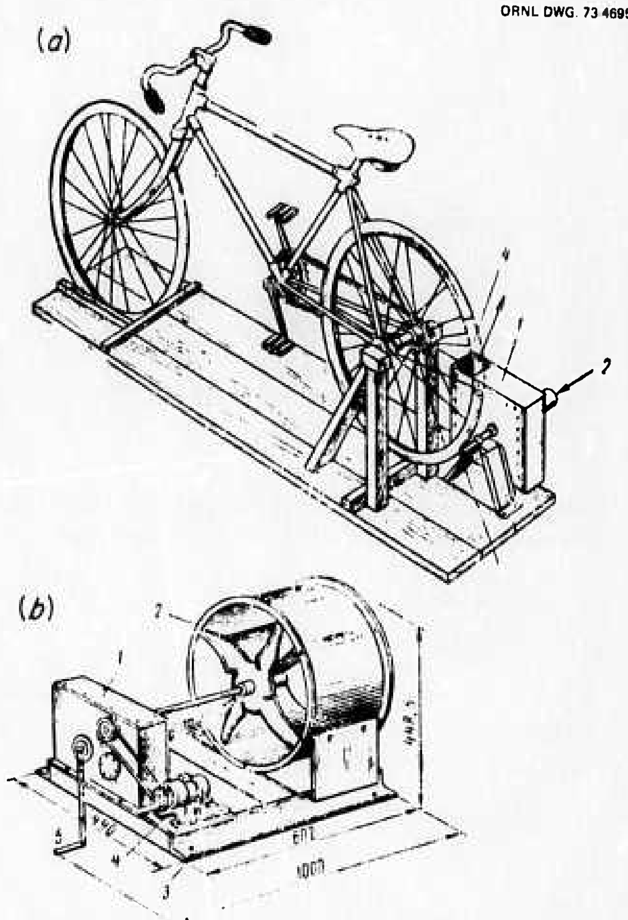

Fig. 60. Fans: (*a*) metal fan with bicycle-driven mechanism – (1) metal fan; (2) intake nozzle; (3) power drive shaft; (4) air outlet: (*b*) ROV axial ventilator – (1) reducer; (2) blade wheel; (3) support; (4) electric motor; (5) crank.

for a given capacity. The flow resistance is measured with a vertical manometer connected to the air duct fitting in front of the ventilating fan and should not exceed 50 mm H_2O.

To assure an air supply in the filter-ventilation system, it is possible to use metal fans with a bicycle-driven mechanism (Fig. 60*a*) (bicycle fans), bellows mechanisms, sewing machine treadles, etc; if electrical power is available, it is possible to use vacuum cleaner motors on ROV axial fans (Fig. 60*b*).

One or two bellows bags are used in the bellows-bag ventilation system. The bellows bag consists of two casings, a bottom, a top, and valves. The inside casing is made of thin canvas, burlap, linen, or cotton fabric, and the outside casing is made of leatherette, rubberized fabric, or film. The bottom and top consist of panels in one or two layers. The ventilation system of one bicycle fan or one bellows provides an air flow rate of 150 m^3/hr [88 cfm] and may be used only in shelters with a capacity of 75 people or less. When outfitting large-capacity shelters, it is possible to use bicycle fans or single and twin bellows mechanisms.

The pit under the filter grating is connected to the ventilation mechanism by metal or wooden ducts. To ensure airtight sealing of the ducts, they are wrapped with any available waterproofing material (tar paper, Pergamyn [wax paper], Rubberoid, etc.). The axial fan ventilator ROV with an electric motor and manual drive mechanism is used to supply ambient air in the clean ventilation system.

A dust-proof oil filter or other filters with a retention efficiency of not less than 90% are installed in front of the ROV fan on the air intake to free the air of radioactive dust. The fan is connected to the air intake duct by a flexible hose. In the case of the filter-ventilation system, the depleted air is removed through exhaust ducts installed in the lavatories and by means of exhaust valves provided in the airtight doors. Wooden deflectors (Fig. 61) and other protective devices are used to protect the air intake and exhaust openings from being penetrated by the blast wave.

The degree of airtight sealing with a simplified system and with a single-stage air exchange must ensure an air

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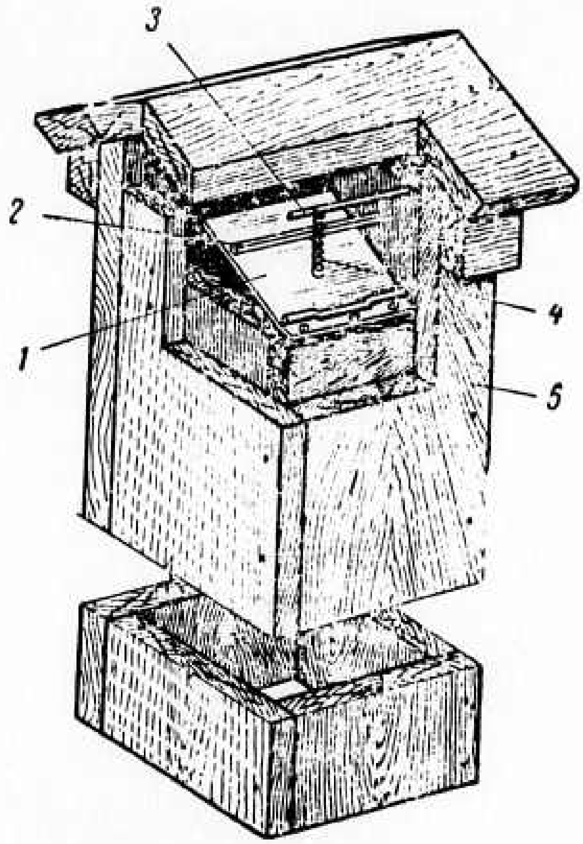

Fig. 61. Wooden deflectors with protective ZU mechanism: (1) valve; (2) valve support; (3) clamp; (4) spring; (5) duct.

pressure of at least 2 mm H_2O. To ensure an air supply equal to a single-volume exchange, the bellows' pumping rate during the filter-ventilation mode is determined according to the formula [see note*]

$$n = 30V/L_{gen},$$

where n is the number of bellows cycles, V is the volume of the shelter (m^3), and L is the total calculated capacity of the bellows.

Rules for using a rugged absorption filter. After a nuclear blast, the filter-ventilation system is turned off for 1 hr and then is turned on again. The rugged absorption filter must be inspected and checked for flow resistance once every two months. The check is to determine the condition of the upper bed layer, the integrity and serviceability of the air ducts, the need for repair, etc. If the bed is very wet and shows greatly increased flow resistance, it must be dried out. The bed is dried by blowing through air of 50 to 60% moisture content for a period of 8 to 12 hr (in the summer in dry weather, in the winter in freezing weather). The amount of materials required to make a rugged filter-ventilation system with a capacity of 300 m^3/hr [175 cfm] is indicated in Appendix VI.

[*Since no time requirements are specified, the editors do not understand the purpose of this formula.]

5.3 HOW TO ARRANGE AND EQUIP FALLOUT SHELTERS

In rural areas, protection of the population is ensured (1) by building fallout shelters and by adapting basements, cellars, and other underground structures as shelters in peacetime and (2) by building and adapting such structures when the threat of enemy attack is announced.

5.3.1 Fallout Shelter in Homes

The fastest and easiest adaptation is fallout shelter in basements (Fig. 62) and cellars (Fig. 63). The basic goal in adapting basements for shelter use is to prevent the entrance of radioactive dust and toxic materials in droplet form into the shelter, as well as to provide protection from external radiation. The shielding of ceilings of basements and cellars is improved by using a poured earth fill or by stacking bricks, etc. Additional

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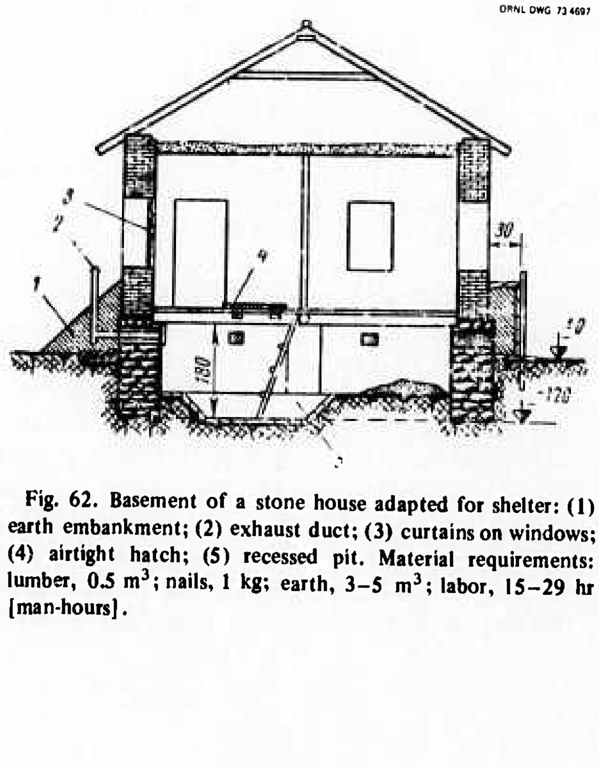

Fig. 62. Basement of a stone house adapted for shelter: (1) earth embankment; (2) exhaust duct; (3) curtains on windows; (4) airtight hatch; (5) recessed pit. Material requirements: lumber, 0.5 m^3; nails, 1 kg; earth, 3–5 m^3; labor, 15–29 hr [man-hours].

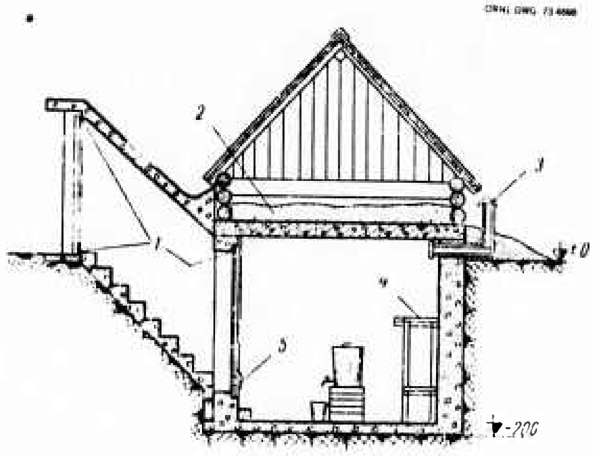

Fig. 63. Detached cellar, adapted for a shelter: (1) placement of airtight doors; (2) earth layer (or slag), 20 cm; (3) exhaust duct; (4) plank bunks; (5) air inlet opening.

supports and girders are placed under the ceiling to avoid damage.

To provide adequately for the extended confinement of people in such shelters, it is necessary to assure a supply of fresh air; provide benches for sitting and plank bunks for resting and a reserve of water and food; set up lavatory facilities; furnish batteries for illumination and a radio transmitter and electrical illumination from the electric power system.

For small-capacity fallout shelter accommodations in basements and cellars (up to 40 persons), ventilation may be achieved by means of natural ventilation through a specially constructed ventilating duct with a cross section of not less than 10 X 10 cm [see note*]. The duct opening is screened with a piece of cloth and closed with a cover. Two such ducts are installed in shelters: one for inlet, the other for exhaust. The inlet duct opening is installed at a maximum height of 50 cm above the floor and the exhaust duct at a distance of 20 to 25 cm below the ceiling. On the outside, the duct must be located at a height of 50 cm above the surface of the earth covering [embankment].

When the shelter capacity is above 40 people, it is advisable to install the simplest filter-ventilation equipment from the materials available.

[*In warm or hot weather, if this shelter were to be occupied for days with even twice the Russian-specified 0.5 m² minimum floor space per person, lethal temperature-humidity conditions would probably result.]

5.3.2 Construction of Detached Fallout Shelters

In addition to using basements, cellars, and other sunken structures, in the civil defense system it is also possible to build detached structures ensuring protection from the blast wave in a zone with pressures not greater than 1 kg/cm², protection from initial nuclear radiation and thermal radiation, and, when airtight sealing and filter-ventilation equipment are present, to ensure protection from contamination by radioactive and toxic materials and biological agents.

Such shelter is made of local materials, sunken into the ground, covered with a layer of loose dirt at least 70 to 80 cm thick, and designed to hold up to 100 people.

Shelter designs may be of various types, but, if made in a rectangular form, the construction of the framework is simplified, facilitating installation and erection work around the foundation. As a rule, shelters have facilities for accommodating people, a vestibule, a heating system, and a ventilation or filter-ventilation system.

Constructing a shelter includes the preparatory work, marking off and surveying the site, excavating the site and constructing drainage, erecting and assembling the framework of the structure and internal equipment, waterproofing the structure, installing ducts and a roof and covering the shelter with earth and with sod. When the shelter proper is being outfitted, it is also provided with filter-ventilation equipment.

After the foundation is excavated and the prefabricated components are installed, the shelter framework should be erected. Shelter frameworks may be constructed of wood, reinforced concrete, or metallic elements. When a shelter framework is built of wood, the following constructions can be used: continuous-frame, frame-block, frame-panel, mitered, and unnotched.

A continuous-frame construction is composed of frames; the frames are fastened at the corners by staples and are joined by nailing. The framework made of frames is assembled manually directly on the foundation.

The special feature of the frame-block construction is that the frames are prefabricated into units which are then set on the foundation. The frame-blocks are assembled with the aid of a motorized crane. Board planks are cut and fastened to the corners of the blocks to ensure lateral stability (Fig. 64).

Essentially, the frame-panel construction is a variation of the large frame-block construction.

The structures just listed may be used only to construct ordinary-foundation, trench-type shelters. In

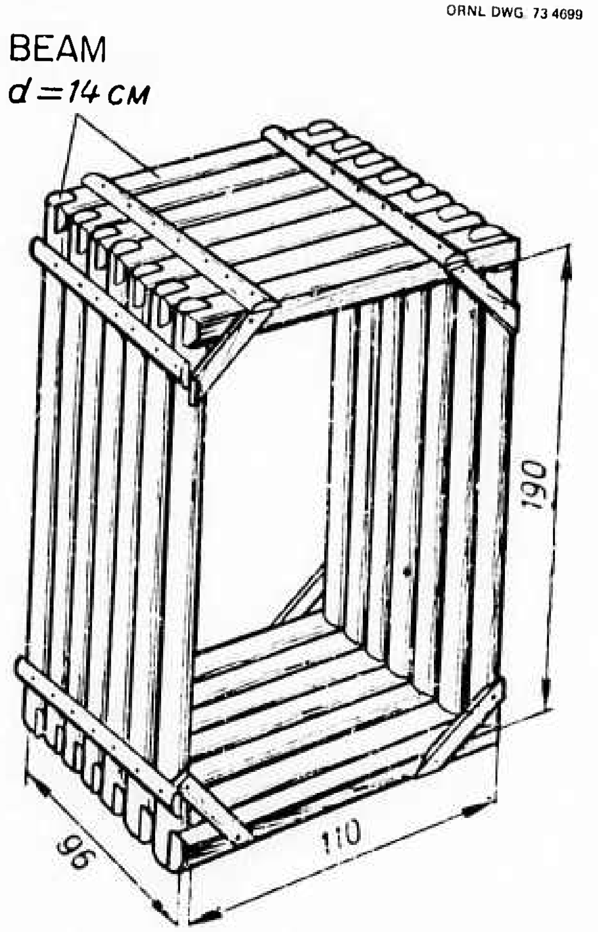

Fig. 64. Block framework for a shelter in frame-block construction.

semi-buried shelters these structures may not be used advantageously because of poor cross-sectional stability. The entrances to these shelters can be constructed only at the face of the framework.

Mitered construction framework can be used to construct either the [trench type] foundation or the semi-buried types. In shelters of the trench type without a rubble base (Fig. 65*a*) and in shelters of the semi-buried type with a rubble base (Fig. 65*b*), the elements of the framework construction are joined at the corners by quarter rounds. To ensure the stability of such a shelter, reinforcing braces are set up in the form of interstitial transverse pieces. Entrances into a shelter with a mitered framework may be built in the front walls as well as in the side walls. Wherever the entrance openings are located, it is necessary to provide not less than two complete miters at the top and the bottom and to insert auxiliary double brackets.

A structure [shelter] of unnotched construction (Fig. 66) is made of poles with diameters of 10 to 14 cm. Supports, framing, and cross braces are connected without notches (only small cuts [are made] in the framing where the braces are installed). The supports [the wall posts] are positioned against the sides of the bracing; the roofing [poles] rest on the upper ends of the supports [wall poles]. To withstand [horizontal] pressure on the corners of the structure, longitudinal poles are installed with cross braces at spacings of 50 to 60 cm, along the length of the structure. At the top, these [horizontal] poles and cross braces are fastened to the framing with twisted wire splices and nails. The expenditure of materials and time required to erect a shelter of unnotched construction is shown in Table 18.

The structure [shelter] made of prefabricated reinforced concrete slabs (Fig. 67) is erected with the aid of a motorized crane. The length of the structure depends on the required capacity (volume) of the structure.

When building shelters, it is possible to use prefabricated reinforced concrete elements designed for constructing heat ducts, communications conduits, large pipes, etc. The joints between the reinforced concrete blocks are sealed from rain water by Rubberoid or other similar material. The norms for the basic types of work in constructing a shelter of reinforced concrete elements are shown in Table 19.

The framework of the shelter may also be made from corrugated Duraluminum components. This kind of framework is preferred because of its resistance and light weight; [also] assembling the prefabricated framework is simple and does not require much time.

The protective cover must be thick enough to protect people in the shelter from contamination by radioactive and aerosol toxic materials, as well as prevent leakage of rain water into the shelter. The average thickness of the cover must be about 1 m. A waterproof layer is usually laid on the ceiling first (roofing) and then a layer of soil with a thickness of 70 to 90 cm.

The weakest part of the shelter is the entrance; thus, it is necessary to provide for its protection. This is achieved by constructing labyrinth entrances with protective doors, vestibules, and airtight entries. The airtight protective doors are made of boards reinforced with planks. The frame of this airtight door is covered with canvas or another fabric impregnated with machine oil; a sealing strip of rubber tubing is mounted on the frame around the door. The doors are hung in gas-impermeable partitions and are closed tightly with clamped bolts.

To prevent toxic materials and radioactive dust from penetrating the shelter, the floor and ceiling at the

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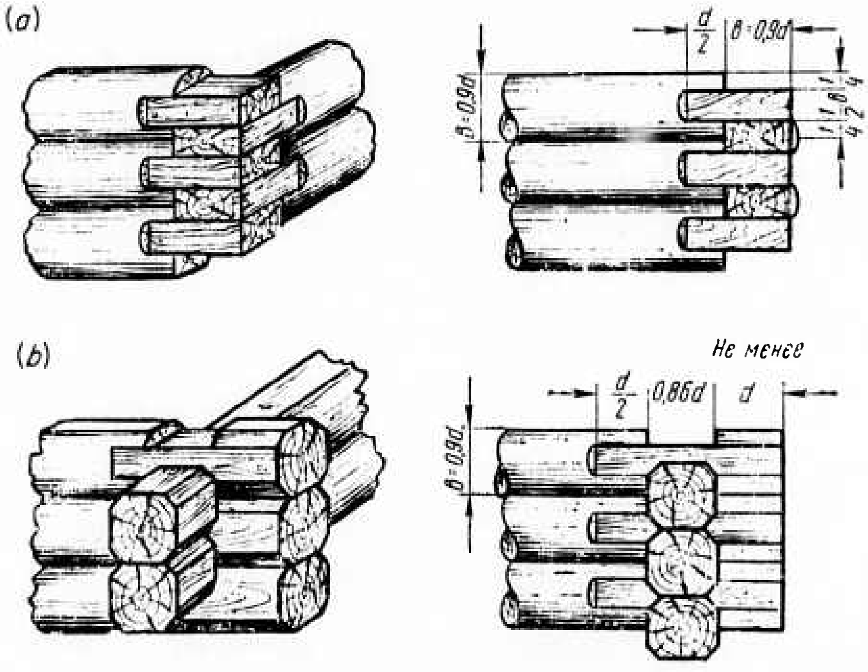

Fig. 65. Connecting framework elements of mitered construction.

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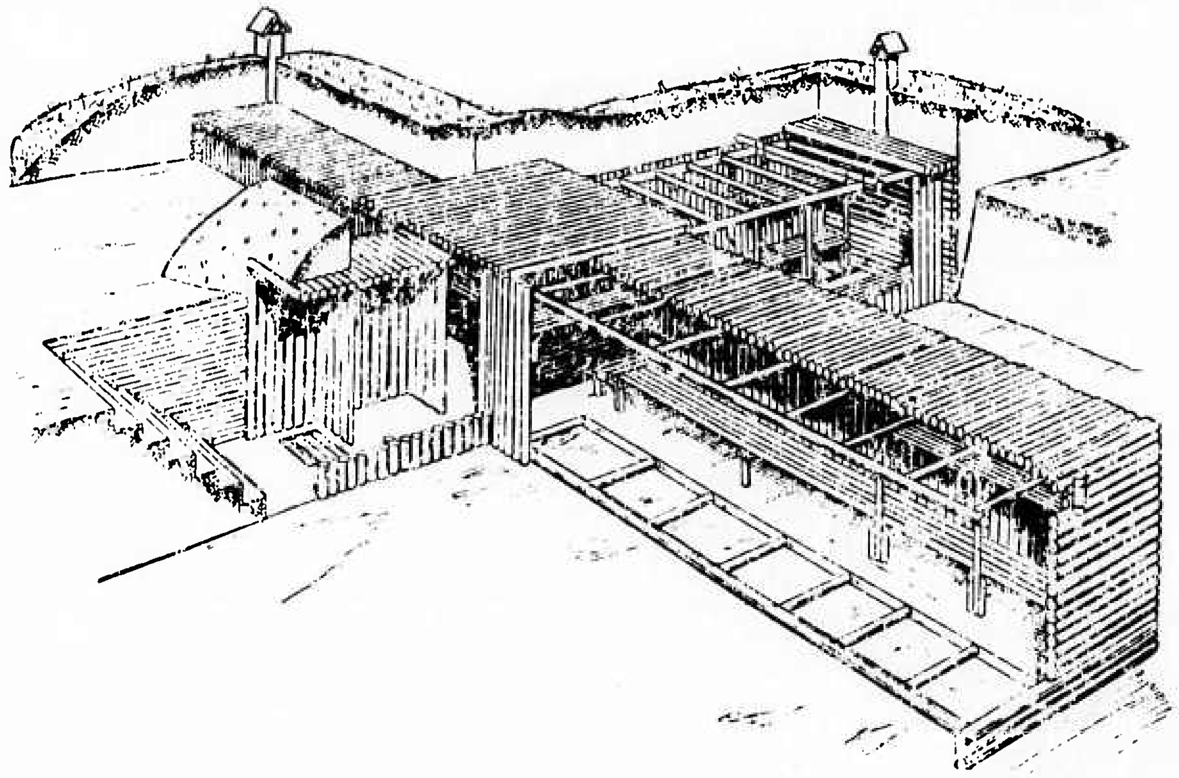

Fig. 66. Shelter of unnotched construction for 40 persons.

Table 18. Materials and time required to erect a structure of unnotched construction

	Single-row [of benches with overhead bunks] disposition		Double-row [of benches with overhead bunks] disposition		
	10 per	20 per	10 per	20 per	40 per
	Material requirement				
Round logs, m³					
subflooring, diam = 8–11 cm	0.1	0.1	3.31	5.28	10.17
subflooring, diam = 14 cm					0.14
poles, diam = 5–7 cm	0.7		0.26	0.29	0.89
poles, diam = 7–8 cm	4.1	6.16			
Total round logs, m³	4.9	6.26	3.57	5.57	11.20
board 2.5 cm thick, m³	0.02	0.04	0.02	0.044	0.07
brushwood, m³	0.4	0.7	0.07	0.1	0.15
nails, kg	0.33	0.33	0.06	0.06	2.7
wires 3–4 mm, kg	3.1	3.72	22.50	30.00	3.20
canvas, m²	4.64	4.64	2.6	2.6	2.6
General weight of materials, kg	3542.0	4605.0	2560.0	3980.0	8260.0
	Labor requirement, hours [man-hours]				
Excavating and digging the shelter foundation	20	34	11	18	47
Preparing the rough construction of the shelter	24	40	18	21	50
Erecting the shelter	86	131	66	86	173
Total labor requirement	130	205	95	125	270

Note: The [material and man-hour] costs for building the plank bunks [benches with overhead bunks] are not included in the table. "Per" denotes persons.

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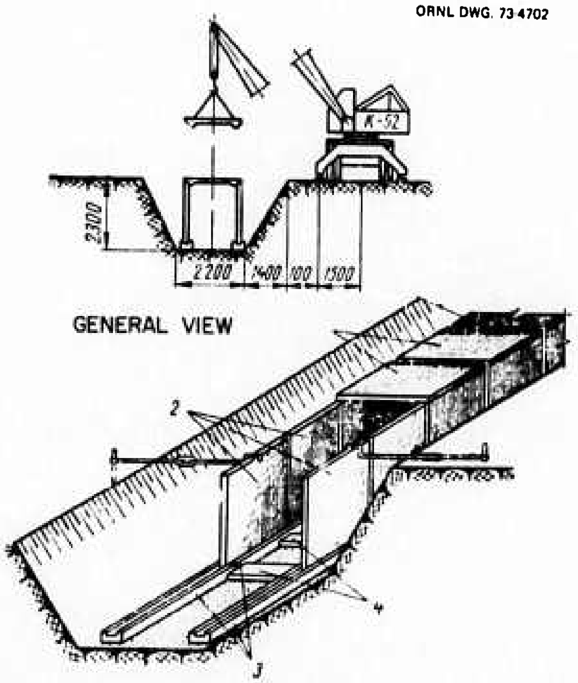

Fig. 67. Installing the shelter with reinforced concrete components: (1) platform of the shelter; (2) platform of the walls; (3) foundations; (4) reinforced concrete cross braces.

Table 19

Type of work	Productivity per hour of work (m³) [ft³]
Excavating a trench manually (medium density soil) [1 man working]	0.4 [14]
Excavating a trench with a power shovel	
E-505	45 [1530]
E-252	22 [750]
E-153 (on Belarus tractor)	10 [340]
Excavating a trench with a bulldozer	18 [620]
Mounting miscellaneous reinforced concrete slabs (team of 4 men), No. of pieces	4 [136]
Mounting miscellaneous reinforced concrete slabs, beams with the aid of hoists (team of 8 men), No. of pieces	2 [68]
Constructing a wooden bracing frame (team of 6 men)	3 [68]

joints of partitions and walls must be offset all around the door frame and 25 to 30 cm outside it.

The interior equipment of a shelter includes plank bunks, lighting, heating, and ventilation. The plank bunks are set along the walls at two levels; the [vertical] distance between the levels [the bunks] must be not less than 85 cm, and from the second level to the ceiling not less than 50 cm. Lighting is provided by batteries, flashlights, candles, or from a dc power supply. The shelter is usually heated with a stove; cast iron stoves, makeshift stoves made of galvanized-roofing sheet metal, or special heaters are provided.

If the shelter is airtight and is planned for protracted occupancy, then it is equipped with simple filter-ventilators and fans made of available material, the construction of which was discussed earlier.

5.3.3 Simple Protective Structures Constructed for the People

In addition to the protective structures which we have considered, the population can, under the threat of enemy attack, construct such cover as [covered] trenches and dugouts by using available materials and their own labor. The trench (Fig. 68) is a narrow ditch with a depth of up to 2 m and a width of 1 to 1.2 m at the top and 0.8 m along the bottom; it is covered on top. To prevent the simultaneous destruction of a large number of trenches, they are excavated in several rectilinear modules, laid out at right angles to one another. Each rectilinear module has a length of about 10 m and is designed to accommodate up to 60 people. Entrances are made at one or both sides of the trench. They are closed with doors which reduce the direct effect of the blast wave to a considerable degree. The entrance into the trench must be offset, oriented at a right angle to the trench.

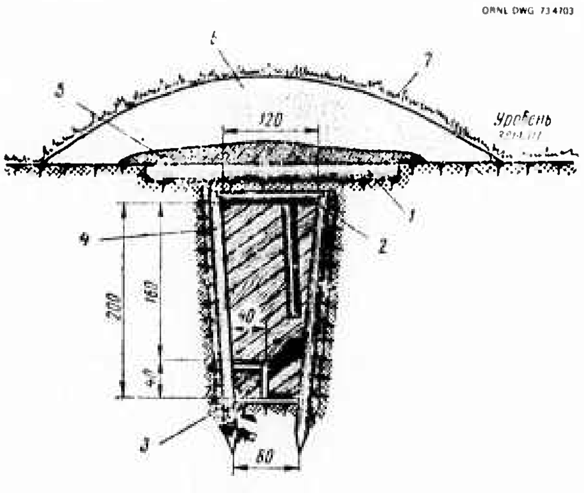

Fig. 68. Trench: (1) roofing (diam 14 cm); (2) cross brace (diam 10 cm); (3) lining of slabs, 18 × 2; (4) stud; (5) compacted clay (20 cm layer); (6) earth covering (60–80 cm); (7) sod.

Where groundwater is near the surface, the trench is semi-excavated so that the floor of the trench is at least 20 cm higher than the possible level of the groundwater. In this case, the part of the shelter that is above the ground is covered with earth. The earth covering must have a slope no steeper than 2:1.

To protect against fire, all the exposed wooden parts of the trench are covered with fire-proofing substances (lime coating, 62% slaked lime, 32% water, and 6% common salt).

Digging a trench begins with selecting a site which satisfies the requirements, the most important of which is that it will neither collapse nor flood Once selected, the site must be surveyed, that is, a site plan must be made. In order to do this, small wooden pegs are driven into the ground at the corner junctions, a string is stretched between the corner junctions, and then the trench is opened up along the string. After surveying [the site], the sod is removed between the survey lines and piled to one side, and the trench is excavated. Digging is begun, not over the entire width, but just slightly within the survey lines. With increasing excavation depth, the walls of the trench are gradually trimmed off evenly and excavated to the required dimension.

After the trench is excavated, the sides are reinforced with boards, poles, brushwood, reeds, and other available material. Then the trench is covered. First, a roofing of logs is placed; then a layer of packed moist clay, with a thickness of 15 to 20 cm, [is placed over it] to protect the roofing from rainwater; next, dirt is piled on the clay to a thickness of 60 to 80 cm; and finally the sod, which was removed before the trench was excavated, is replaced. A drainage ditch is dug on the trench floor, with a water-collecting sump situated at the trench entrance.

Benches and stands for water containers are built along one of the walls. A drainage ditch is dug around the trench so that surface water will not enter the trench.

Dugouts [underground peasant's houses or "mud huts"] (Fig. 69) are shelters intended for a prolonged occupancy and may be used as temporary dwellings for people left without housing. Therefore, dugouts are more completely equipped than trenches. They are

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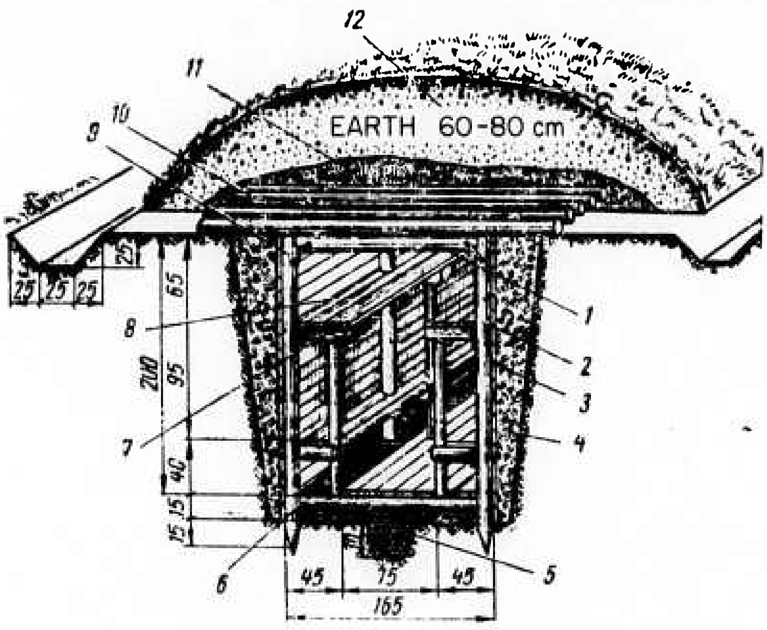

Fig. 69. Dugout: (1) cross braces (diam 16 cm); (2) support (diam 16 × 90 cm); (3) lining of boards, logs, or split poles; (4) compacted clay; (5) drainage; (6) cross braces (diam 12 cm); (7) planks (5 × 10 cm); (8) boards (25 cm); (9) brackets; (10) roofing (diam 16 cm); (11) compacted clay (20 cm); (12) earth covering (60–80 cm); (13) sod.

provided with heating, a vestibule, double doors, a portable toilet, small water tanks, and along the walls there are tiered plank bunks, the upper for sleeping, the lower for sitting. Dugouts can be sealed airtight and have a simplified filter-ventilation or merely a ventilation system.

Ideal dimensions for the dugout are about 2 m wide X 2 m high, with the length depending on the number of people it shelters, but not less than 3 m. The walls of the dugout may be of logs, boards, or other available material. The roofing is made of a continuous log ceiling (diam 18 cm). The roof is covered with a packed bed of moist clay, with a thickness of 20 to 25 cm, for waterproofing. The moist clay is also packed between the lining of the walls and the walls of the foundation. It is possible to use tar paper, rubberoid, etc., for waterproofing. A layer of at least 70 cm of earth is piled on the clay and is then covered with sod. A drainage ditch is constructed under the floor of the dugout, with a sump situated at the entrance to the dugout. The entrance to the dugout is stepped; with respect to its protective characteristics, the best entrance is a covered trench.

When the groundwater level is [quite] high, the mud hut can be built partially sunk into the ground. In these cases, the part of the mud hut projecting above the ground is covered with earth, while the embankment must have a grade of not less than 1:2.

5.3.4 Shelter Made from Fascines

In the absence of the structures and materials considered above, it is possible to construct a fascine shelter of dry branches or reeds, canes or stems, or agricultural plants and other similar available materials. The fascines are bound brushwood [bundles made of canes or sticks], each stick up to 3 cm in diameter, held together by soft wires 1 to 3 mm in diameter. Wires are tied [around a fascine] at a distance of a diameter [of the fascine] from its ends, and subsequent ties are made at two diameter intervals. Arched fascines 25 cm in diameter made of cane reeds, or 20 cm in diameter if made of sticks, are used for the roofing.

A shelter for ten persons with a covering made of arched fascines is shown in Fig. 70. The arched fascines are laid closely touching each other and are lashed longitudinally with a single wire, with a total of eight wires being used at the ends and center parts of the fascine. It is possible to join the fascines with wooden poles, 3 to 4 cm in diameter and 60 to 65 cm long, wedging them in checkerboard sequence at every other pair of fascines. As a result, the separate fascines are converted into a continuous arch which supports a significant load.

Special attention needs to be paid to the ends of the fascines, which are cut off to form an even surface perpendicular to the axis of the fascine. The ends of the fascine must be tied not more than 20 to 25 cm from their end planes. The entire surface of the end planes on the fascines must rest on the ground. If this is not possible, an earth bank is placed under the end plane of the fascine so that it rests tightly against the ground.

On loose or weak soil, the sloping part of the roof is covered with poles while supports are placed between the arched fascines and tied together with wires. If poles are unavailable, hooped fascines are used which simultaneously form the roof and the walls of the shelter (Fig. 71). This type of shelter requires a great deal of materials and time to prepare and construct compared with the shelter of arched fascines (Table 20).

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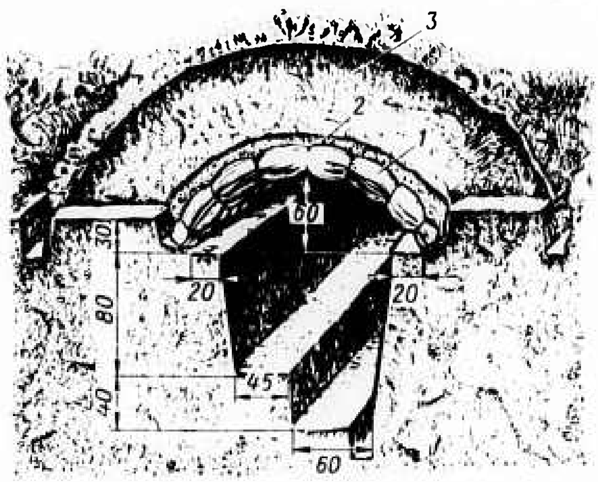

Fig. 70. Shelter in clay ground with a covering of cane-reed arched fascines: (1) fascines; (2) layer of compacted clay 3–5 cm thick; (3) soil layer 70–80 cm thick.

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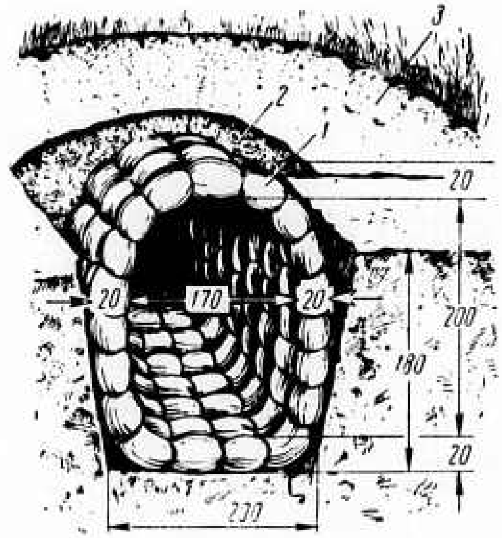

Fig. 71. Shelter in sandy soil made of annular brushwood fascines: (1) fascines; (2) layer of compacted clay 3–5 cm thick; (3) soil layer 70–80 cm.

Table 20. Basic materials and time costs for constructing a shelter of fascines

Name of materials and designation	Shelter for 10 persons				Shelter for 20 persons		Shelter of hooped framework	
	Single row		Double row		Double row			
	Without covering of the sloping part	With covering of the sloping part	Without covering of the sloping part	With covering of the sloping part	Without covering of the sloping part	With covering of the sloping part	10 Persons	20 Persons
Cane reeds (brushwood), m^3	12	13	11	10	17	15	15	23
Poles, m^3	0.04	0.6	0.04	0.5	0.04	0.6		
1 mm wire, kg	4	4	3.5	3	5.5	4	7.5	13
Canvas, m^2	17	10	17	10	17	10	16	16
No. of persons in brigade	12	12	12	12	14	14	12	16
Preparation of basic components for cover, hours of labor	40	35	30	25	50	40	75	105
Building the shelter, hours of labor	80	85	75	80	110	105	95	150
General construction time, hr	11	11	9	9	12	11	15	16

5.4 USE OF MINES AND MINE SHAFTS FOR SHELTERS

To shelter the population in mining regions, it is possible to use coal mines, ferrous and nonferrous mines, mines for extracting building materials, catacombs, caves, etc. The protective characteristics of mines and other shafts are much greater than those of the detached blast shelters and fallout shelters which are usually built.

Adaptation of a mine for shelter must be made in advance, in peacetime. Primarily, the preparations for radiation shielding and simple measures for shockwave protection are completed first, followed by the rest of the work required to achieve the maximum degree of protection and the maximum capacity. The basic preparations for adapting a mine as shelter include:

1. constructing protective and airtight partitions; adapting the entrances for rapidly moving people into the mine and constructing emergency exits from the mine; preparing vertical staircases or ladders and emergency elevators for people;
2. supplying air to the occupants by means of one of the following modes:
   a. a constant volume of air [forced and unfiltered];
   b. a system of natural ventilation, with [a capability for] switching over to a constant-volume mode (in 2 hr);
   c. filter-ventilation system with the air freed of radioactive dust with the ERV-49 unit;
3. ensuring a water supply for the occupants by using mine water, water in fire hose pipes, and water reserves stored in mine cars or in mine reservoirs;
4. preparing sanitary facilities in isolated mines by using mine cars or water-collecting channels, along which the waste water can be drained off into lower unused levels;
5. developing a system of control points, medical units, and storerooms to keep food supplies;
6. constructing plank bunks for sitting and sleeping;
7. creating a system of electric lighting and radio communications.

In mines, shelter can be set up in the form of tunnels consisting of several rectilinear units arranged in a square shape with two entrances and exits or in an L-shape with one exit and one entrance. The width of the tunnel is 1.2 to 1.5 m; the height is 2 m. The capacity of one rectilinear unit is a maximum of 20 people (Fig. 72).

The walls and the ceiling of the tunnel are reinforced with stable wooden or reinforced concrete frames, props, or cross beams. A protective wall is placed in front of the tunnel, forming a through-passage; a vestibule with two doors is constructed at the entrance. Benches and overhead bunks are arranged inside the tunnel, which is furnished with light and heat and, when there is airtight sealing, with a simplified filter-ventilation system.

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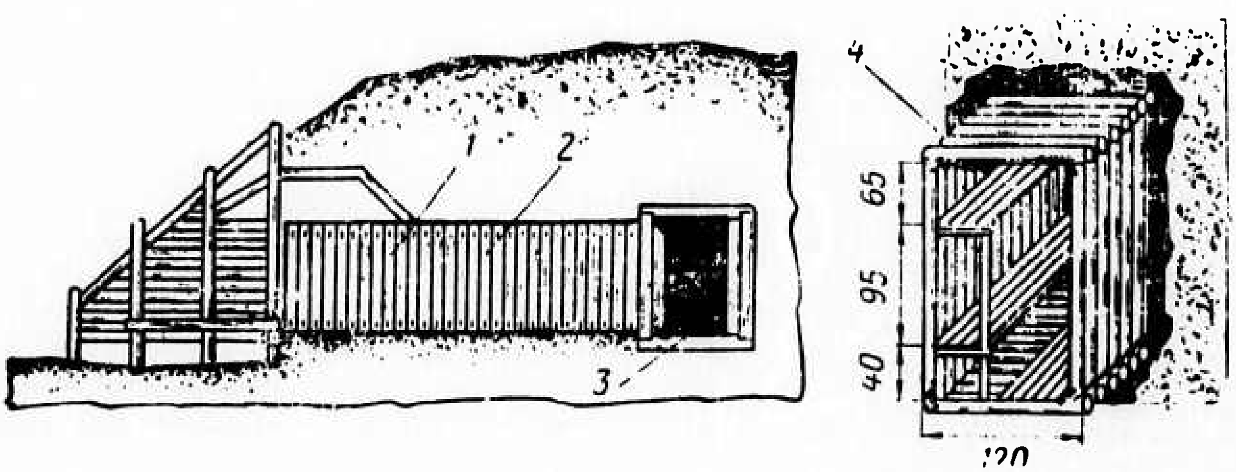

Fig. 72. Tunnel (cross section): (1) entrance; (2) wooden frames; (3) tunnel; (4) frames made of logs or beams.

5.5 RULES FOR USING THE SHELTER

5.5.1 Reception and Contents of Shelters

The shelter is made operational after it is approved by the appropriate inspection commission. The order under which the inspection commission operates, as well as the total documentation which must be presented to the commission, is indicated in the section on building standards and rules of the SN&P III-A. 10-62, "Approval for Use of Completed Architectural Undertakings, Buildings, and Structures (Basic Assumptions)." Only those shelters in which construction is complete and the equipment is installed and assembled are approved for use.

On each shelter there is a diagram, a small map relating the shelter to obvious landmarks, and a map for evacuating people from the shelter. The diagram shows the ventilation ducts in the wall; the air intake system; the water supply, sewer, heating, and electrical lighting networks; the location of the cutoff mechanisms; the emergency exit; the thickness and the material of the walls and shelter roof; the interior area and cubic volume of the premises. A table is given indicating the permissible confinement time with a constant air volume (depending on the number of occupants).

The shelter map shows the shelter location and its disposition with reference to characteristic, permanent local landmarks, by which it is possible to rapidly find an obstructed [buried] shelter.

The plan for evacuating people beyond the city limits indicates some possible routes from the area of departure to where the shelter is located. Foot routes are selected along the least obstructed streets and through regions where no group fires are expected to break out. Reliable and easily recognizable landmarks are plotted on the foot routes. This document is developed in peacetime, and two copies are made: one [to be left] in the shelter itself, the other with the CD staffs.

After all construction, installation, and cleaning work are finished, the structure is checked for airtight sealing. The degree of airtight sealing of the shelter is determined by the magnitude of the air pressure. A check for airtight sealing should proceed as follows:

1. close all the entrance doors, shutters, and hatches;
2. plug the overpressure ducts; close the airtight valves and plugs on the air-water outlet system;
3. start the inlet air supply system for the purified ventilation system;
4. determine the amount of air entering the shelter;
5. measure the air pressure head in the shelter.

When the filter-ventilation unit is switched on, air will enter the compartments, creating an overpressure inside the premises. It is possible to evaluate the amount of air which has entered by the flowmeter on the filter-ventilation unit. Knowing the capacity of the filter-ventilation unit and the interior volume of the shelter being tested for airtight sealing, it is possible to determine the "multiplicity" factor of the air exchange according to the formula

$$K = Q/V ,$$

where Q is the amount of air which has entered (m^3/hr) and V is the volume of the airtight sealed shelter area (m^3).

The air pressure head is measured with an inclined manometer of the TIIZh type (liquid level), one leg of which (having the lower pressure) is connected to the duct connected to the ambient air. The pressure head must be at least 5 mm H_2O on all ventilation systems in the shelter. Depending on the air-exchange multiplicity factor, the air pressure head must correspond to the following magnitudes:

With an air-exchange multiplicity factor	0.5	0.6	0.8	1.0	1.2	1.4
Required pressure head in mm H_2O	5	6	8	12	15	18

If the air pressure head is insufficient, then the location of the leak is determined by flame deflection with a match, in addition to which the following are checked:

1. the condition of the seal on airtight doors and shutters, as well as the operation of the lock mechanisms (wedge-shims);
2. the fit of the door panel (shutters) with the sealing structures and door seals (sealing strips) to the door (shutter) frame;
3. airtight sealing of the penetrations of various inlets through the protective structure;
4. airtight sealing of the joints of the ceiling and the floor with the surrounding walls, joints between blocks, and seams between structural components, especially in entrances (vestibules).

The airtight seal of the shelter is checked by periodic inspections (at least once every three months) and also immediately after it has been occupied, after an "air raid" alert.

During the period of shelter occupancy, it is necessary to maintain a pressure head of 5 to 7 mm H_2O. It is assumed that with [such] a pressure differential, toxic vapors cannot enter the shelter.

To ensure the safety of the structure – the interior equipment and the contents – the entrance doors as well as the shutters of the emergency exits are locked and opened only for maintenance and ventilation. A list is hung on the entrance doors which indicates where the keys are kept, the responsible members of the group (shelter managers), their work and home addresses, telephone numbers, and the shelter number. The locks to the doors and shutters must have at least two keys. One set of keys is kept by the shelter manager and the other by the plant (business, institution) maintenance man in the plant supply office, or in the technical inspection building.

It is recommended that the filter-ventiliation chamber be kept closed. The protective-sealing valve on the emergency air intake must be kept closed, and the sealed double valve closed and sealed in position, thus preventing flow of air through the absorption filter under ordinary conditions. (In addition, the right stem of the double valve must be kept in its extreme left position.) Otherwise [i e., if these instructions are not followed], the filters may become damp and ineffective when using the unit to ventilate the shelter, especially in wet weather. The oiled dust filters installed in the expansion chamber or in the emergency exit may be removed for better preservation in peacetime and stored in the filter-ventilation chamber.

To prevent condensation, the inlet air blower of the ambient air is insulated with felt or other materials. To prevent warping and to increase the life of the rubber gaskets on the airtight doors and shutters, they are, as a rule, left open, and the airtight blast doors and manhole shutters are closed so that the rubber packing does not become pinched. The cutoff valve (KOP) must be systematically inspected; to prevent corrosion, the stem and the inner surface of the valve are lubricated with commercial grease, and the exterior metal parts are painted with oil paints.

The gravel shock attenuator must be washed with water not less than one to two times per year; the washing is done with a fire hose or by hand with pails. After washing the gravel, the water is collected in a special pit, or it flows through an opening into a drip pan of the shock attenuator. This water is removed from the tunnel of the emergency exit. The overpressure valves or the protective-hermetic dampers on the exhaust duct in the lavatory must be adjusted and have the proper rubber packing. It is necessary to systematically check the water pipes, sewer pipes, electrical system, and telephone and radiocommunication lines to make sure that they operate properly.

The filter chamber must have spare parts in a kit along with the filtration unit, an instruction guide of the filter-ventilation unit (Appendix VII), a list of the shelter personnel, and a floor plan of the shelter. A poster is hung on the wall of the chamber showing how to operate the filter-ventilation unit and the ventilation system (Appendix VIII) and [also giving the] rules of conduct for the shelter occupants. The list of documents and diagrams which are recommended for the shelters and the equipment table are given in Appendices IX and X.

Maintaining the proper temperature and humidity in shelters is very important for maintaining the shelter and its equipment in good condition and for maintaining normal conditions of shelter occupancy. In winter the temperature in the shelter must not be lower than +10°C [50°F] and, as a rule, not higher than +15°C [59°F]. To keep the temperature within these limits, it is necessary to ventilate the shelter regularly by opening the doors and briefly using the filter-ventilation unit of the purified ventilation system.

When the shelter is to be ventilated, it is necessary to take into account the temperature and humidity of the ambient air. In the warm season of the year, ventilating should be done only at night, and during the fall-winter period, at the warmest time of day. Ventilating is not recommended when it is raining and is forbidden in foggy weather. The recommended schedule for ventilating a shelter is shown in Table 21.

Table 21

Season of year	Hours most favorable for ventilation	Ventilation methods	Duration of ventilation
May 15 to Aug. 31	24–6 hr [Midnight–6 AM]	Natural	Not less than 3 hr without interruption
Sept. 1 to Oct. 31	In clear weather, from 12–18 hr	Natural	From 2–3 hr without interruption
Nov. 1 to Mar. 1	Any time of day	Natural	In short intervals of 20–30 min; two–three times with interruptions of 30 min; with freezing temperatures not lower than 20°C [–4°F]
Mar. 1 to May 15	7–11 or 18–22 hr	Natural	From 2–3 hr without interruption

Information on relative humidity can be obtained from the local weather station. The relative humidity in a shelter usually is determined by an instrument called the psychrometer. The simplest method for determining the optimum period for ventilating, that is, when the ambient air which has entered the shelter will not precipitate (condense) moisture from the shelter air, is as follows: place a bottle of water on the floor; then, after a short period of time (30–40 min), carry it into the street; if the bottle is covered with dew, the shelter must not be ventilated, since ventilation would cause moisture to condense on the walls and on the metal parts. When the humidity in the shelter is higher than permitted, it is necessary to quickly find the cause for the excess humidity and take measures to eliminate it.

5.5.2 Shelter Maintenance

Responsibility for shelter maintenance in wartime falls to the Blast and Fallout Shelter Service in plants, institutions, and organizations which have personnel using these shelters. For each shelter a maintenance team of seven persons is designated, headed by the team commander who is the shelter commandant [manager]. The maintenance team of the shelter is equipped with the following year:

Gas masks for each member of the team
A light protective suit "L-1," 2 sets
Rubber gloves, 2 pairs
Chemical survey equipment, type PXR or VPXR-1
Dosimetric equipment (DP-63, DP-5, etc.), 1

The commandant [shelter manager], with the other members of the shelter team, inspects the shelter, helps check the filtering unit, checks the airtight sealing and the equipment, and helps to set up the telephone equipment and the radio transmission stations. The team services three posts (two persons at each post).

Post No. 1 (double shift, around the clock, at the entrance). When the shelter is being filled, one attendant keeps watch outside the shelter at the entrance, admits people, and keeps order; the second [attendant], at the entrance inside the shelter, assigns the occupants their places in the shelter, and assists those with children, the sick, and the old. When the signal is received to close the doors, the person on duty closes the doors and remains on duty at the entrance, and the second one helps maintain order within the shelter and then rests before returning to his duties.

Post No. 2 (double shift, around the clock). The people at this post check and prepare the filter-ventilation mechanism for operation under the orders of the team commander (shelter commandant), turn it on, and oversee its operation. The sequence for turning on the filter-ventilation equipment is shown in Appendix VIII.

Post No. 3 (double shift, around the clock). Before filling the shelter, this post turns on the lights and closes the manholes and the regulating dampers of the exhaust system; if necessary, closes the passageways and then assigns people to their places and orders their confinement in the shelter.

If the shelter has diesel equipment or artesian wells, the team should include specialists to maintain them.

The shelter manager must give instructions to the members of his team and guide them in fulfilling their duties; pay special attention to CD signals; be well acquainted with the proper use of the shelter and its equipment; know the layout of the shelter, the location of the emergency exits, the possible exits through basements adjoining the shelter, and the location of nearby sheltering structures. He must also know the location and designation of the basic communications systems near the shelter, the inlet location of electrical networks, water pipes, the sewer system, etc., and know how to use the disconnecting mechanisms; know the locations of the local CD staff telephones, the nearest fire brigades, and the medical facilities. He must check the inventory in the shelter, check the firefighting and emergency equipment, according to the shelter inventory list, and supply what is lacking; make sure that the shelter can be quickly readied for use, ventilated regularly, and kept clean and orderly; personally check the operating conditions of interior shelter equipment (especially the filter-ventilation equipment) and take measures to quickly correct defects; check the operating condition of the telephone and the radio.

At the "air alert" signal, the shelter manager, along with the shelter team personnel, must report immediately to the shelter. The team personnel go to their posts; the command is given to switch off the heating system and switch on the ventilation equipment, using the purified ventilation mode; the occupants are admitted and assigned spaces in the shelter, and the rules of shelter conduct are observed.

On the signal "close the protective structure," or when the shelter is filled, the doors and shutters are shut, and the shelter is supplied with air by the purified ventilation mode. In addition:

1. the ventilation equipment of the purified ventilation mode must be turned on;
2. the airtight valves and other airtight equipment must be open if they are installed on the air-water clean ventilation system, and there must be absorption filters on the bypass lines;

3. the airtight valves in front of and behind the absorption filter must be closed, and also the valves both before and after the filters that purify the air from carbon monoxide.

On the signals "chemical attack" and "bacterial contamination," the air supply system is immediately connected to the filter-ventilation system. When making the transition to the filter-ventilation mode:

1. the following are shut off! [1] the airtight valves in the airlines of the clean ventilation mode and the valves in the bypass channel of the filter absorbers and [2] the protective and airtight units placed in the emergency exit used as an air intake duct in the purified ventilation mode;
2. the exhaust fans and the inlet air fans of the clean ventilation system are stopped;
3. the sealing and damper equipment on the exhaust ducts is closed (adjusted);
4. the airtight valves in front of the absorption filter and the heat capacity filter are opened;
5. the inlet fans of the filter-ventilation system and the exhaust fans (if their operation has been provided by a given ventilation system) are started;
6. after a nuclear blast, the ventilation system is turned off, all the air-water ducts and openings are shut, and the conditions outside are determined. No longer than 30–40 min after the blast, the ventilation system required in the complex situation is switched on.

If fires occur and if more than 0.02 mg/liter of carbon monoxide is detected in the inlet air, the filter for purifying the air from carbon monoxide and the equipment for renewing the inside air are turned on; then, the ambient air should be supplied only in order to maintain the air pressure head (not less than 1.5 mm H_2O), using a total volume equal to 0.3 of the volume of the shelter [? per hour ?]; the exhaust ducts and openings are completely closed off. After the fire, the heat capacity filter and the filter for freeing the air of carbon monoxide are disconnected.

5.5.3 Order for Occupying and Leaving the Shelter

Admission to the shelter must be orderly. Children and old people are admitted first. People arriving at the shelter with children are arranged in a separate compartment or in a special place set aside for them. Assignments are made according to the instructions of the shelter manager and the team members. The shelter team personnel must carry distinguishing identification, for example, arm bands.

Exit of anyone from the shelter is forbidden without the express permission of the shelter manager. Occupants must obey all orders of the commandant [manager] concerning conduct in the shelter, and the manager must help maintain proper order.

The occupants are obliged to bring a two-day food supply in polyethylene or oilcloth bags, toilet articles, as well as essential personal items, documents, and individual means of protection (gas masks, respirators, etc). It is forbidden to bring easily flammable or strong-smelling materials, unwieldy objects, and domestic animals into the shelter. It is also forbidden to go needlessly to the shelter, to make noise, to smoke, to burn kerosene lamps, candles, and homemade lamps without permission.

In the shelter, conversations, reading aloud, and use of the radio receivers are recommended. These measures are carried out on the instructions of the manager with a group of the shelter team members or occupants. People can leave a shelter on the instructions of the manager (after receiving the signal "all clear" or in the case of an emergency in the shelter which threatens the lives of the people) and do so under the direction of the shelter team personnel.

With damage or collapse of the shelter, the shelter manager (team commander) evaluates the risk of continuing shelter occupancy and, without waiting for assistance from rescue units from outside, arranges for the doors to be opened and the rubble cleared from the entrances and emergency exits, choosing some of the occupants for these tasks.

First the entrance is opened. This is done by releasing all the locks and partially prying the door open with a crowbar and wedges. If these measures are not successful in opening the entrance door, then (in the case of a flat door panel) the door can be removed from the hinges by means of a crowbar or wedge. In a curved door panel (thickness 3–5 mm), with the aid of drills, chisels, and hand saws, an opening is made through which rubble is moved to the inside of the shelter, and it is possible for a few persons to crawl out and remove additional rubble from the entrance. Along with the work of opening the door and freeing the entrances of rubble, some of the people are directed to clear away possible rubble from emergency exit tunnels.

After the work of opening entrances or emergency exits has been completed, the shelter manager arranges for determining the degree of radioactive or chemical contamination in the area where the shelter is located and also for establishing marching routes for moving evacuees from the shelter. Depending on the results of the reconnaissance, the manager decides on the advisability of the occupants vacating the shelter.

Evacuation of occupants from the shelter proceeds in the following manner: first a few persons go outside to help those occupants who cannot leave the shelter independently, then old people and children are evacuated, and finally, everybody else.

6. Technological Civil Defense Measures to Increase the Continuous Operation of National Economic Installations [Facilities]

To wreck the enemy's economy has always been the purpose of war. Even in the First World War, adversaries tried to use air power to disrupt the rear of the enemy. But at that time, aviation was not in a position to do this. In the Second World War, the German fascists attempted to disrupt England's economy by bombing large cities with airplanes and rocket strikes. "Thus the German fascist command launched 4320 FAU-2 rockets on England and Belgium. Each rocket carried a few hundred kilograms of conventional explosives. The explosions of the FAU-2 warheads inflicted great damage on London and other cities. In London 2724 people were killed and about 6500 wounded. In Belgium more than 4000 people were killed by the FAU-2. In England more than a million homes were damaged. But Fascist Germany was unable to succeed in its goal of destroying industry and putting England out of the war."* In turn, the allies attempted to undermine Fascist Germany's economy through systematic raids on targets in the rear and achieved considerable success. However, they were not able to disable completely the industry of Fascist Germany.

Through modern nuclear missiles, targets in the rear are damaged much more effectively than in the past. Missiles can destroy targets at any point on the earth's surface, and nuclear weapons make it possible to destroy an entire city with one blast. Under conditions of nuclear missile war, destroying large administrative-political and industrial centers may be one of the high priority goals of the enemy. The combat commanders of imperialistic countries have more than once discussed massive nuclear attack on cities and other targets in the rear of our country.

Our enemies plan to inflict nuclear strikes not only on military targets (rocket bases, troop concentrations, airports, and communication centers), but also on densely populated areas and national economic facilities. Other populated areas not under direct attack may find themselves in a zone of radioactive, chemical, or biological contamination.

The larger the city, the greater its probability of being selected by the enemy as a target of nuclear attack. In conformity with building standards and rules,* all cities can be classified into the following groups:

1. very large cities, with a population of 250,000 to 500,000 people;
2. big cities, with a population of 100,000 to 250,000;
3. average cities, with a population of 50,000 to 100,000;
4. small cities, with a population of less than 50,000 people.

The threat of destruction to large industrial centers and other important targets makes it necessary to execute civil defense measures and to increase the operational stability of national economic facilities in time of war. Technological measures are carried out first in very large and large cities and in important potential targets.

6.1 THE CONCEPT OF ZONES OF POSSIBLE DESTRUCTION IN A NUCLEAR BLAST

To plan technological measures, the CD staff of a city or of a national economic facility must estimate the power of the munitions which the enemy may use on the city or other target. To do this, they must try to

Revolution in the Affairs of War, Voenizdat, 1967, pp. 18–20.

**Building Standards and Rules*, Part II, Sect. R, p. 3. Publishing House on Literature Concerning Building Construction, 1967.

put themselves in the enemy's place. The enemy, in preparing an attack, determines the nuclear power required to destroy a city or any [other] given target by taking into account the importance of the city target as an administrative-political and industrial unit, and its geographical area, as well as the probability of destruction, by calculating the deviation of the nuclear weapons from the target due to scattering.

According to foreign data, to calculate the strikes on cities it is customary to use the magnitude of the blast wave overpressure equal to 0.3 kg/cm^2 [4.3 psi]. Such overpressure causes great damage to dwellings, as well as to industrial buildings.

The area of destruction caused by the nuclear explosion is approximately the shape of a circle. Thus, if the city is built compactly, then its geometrical center is the target point (Fig. 73*a*). The distance to the outskirts is the radius of destruction. For cities that are not built compactly, the force of the nuclear blast is usually selected so that the radius of destruction equals half the distance from the center of the city to its most distant outskirts (Fig. 73*b*).

So the first step in estimating the power of nuclear weapons to be used on a city is to measure the radius from the center of the city to its outskirts. Then, according to the overpressure and the measured radius, one finds the appropriate power of the nuclear weapon in Table 4 (see p. 26).

The CD staff of a city determines the size of the zone of possible complete, high, moderate, and slight destruction. From the center of the city, the perimeters are drawn of the zones of destruction, assuming maximum deviation of the missile and a given power of the nuclear explosion; these [factors] will delimit the zones of possible destruction which must be taken into account when planning civil defense measures (Fig. 74).

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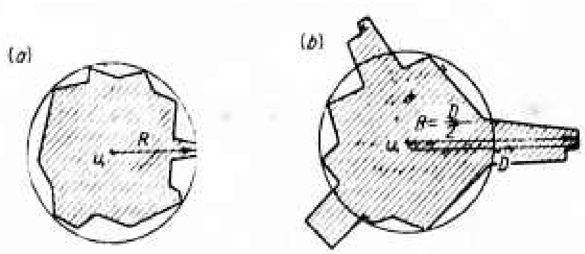

Fig. 73. Determining the power of a nuclear blast which may be used on a city: (*a*) city with high building density; (*b*) city with low building density.

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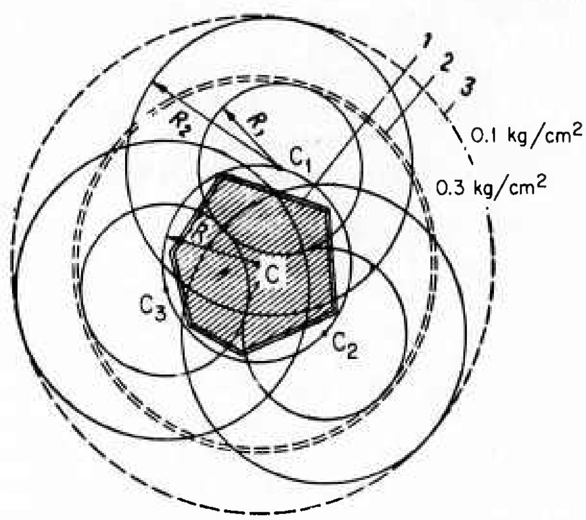

Fig. 74. Sketch for determining the boundaries of the zone of possible destruction of a city from a nuclear blast: C = geometric center of the city and target point; R = radius of the rocket scattering circle [a rocket can land anywhere within this area]; R_1 = radius of destruction of a single nuclear explosion with 0.3 kg/cm^2 [4.3 psi] overpressure with maximum deviation of the rocket; R_2 = radius of destruction from a single nuclear blast with 0.1 kg/cm^2 [1.4 psi] overpressure with maximum deviation of the rocket; C_1, C_2, C_3 = possible centers of nuclear explosions; 1 = boundary of urban buildings; 2 = boundary of possible heavy destruction from 0.3 kg/cm^2 overpressure; 3 = boundary of possible slight destruction from 0.1 kg/cm^2 overpressure.

Since we do not know which cities and industrial sites will be the target of nuclear attack, it is necessary to take CD measures in all cities, all population centers, and every national economic center. To ensure the stable operation of industry under conditions of nuclear war, a large complex of organizational and technological measures are taken. These measures are taken on a republic-wide scale, as well as in cities and national economic establishments.

Measures may be taken nationally to limit the concentration of industry in certain regions. A rational and dispersed location of industries in the territories of our country is of great national economic importance, primarily from the standpoint of an accelerated economic development, but also from the standpoint of organizing protection from weapons of mass destruction. A uniformly dispersed distribution of plants may be accomplished gradually by developing industry in underdeveloped regions and limiting the construction of new plants in highly industrialized regions. The enormous territory of our country and its very rich natural

3. disposition of food supplies, water, medical supplies, and protective means for the combat organization of the command post.

To fulfill these requirements the facility's command post has:

1. a command room;
2. an operations room for location of the reconnaissance operations section and the telephone operator;
3. a room for the service chief;
4. a lounge;
5. a communications terminal where the communications group is located;
6. sanitary facilities;
7. warehouses and chambers for the units.

The command post may be located in a basement of a detached belowground structure specially constructed for this purpose. It ensures continuous radio communications and is equipped with an antenna for radio operation. The command post operates by transmitting verbal orders (instructions) over wire and radio or using signal and portable communication facilities.

The administrative survivability of a command post depends on uninterrupted communications. Thus, as a rule, the communications unit is located in the command post itself or, in exceptional cases, in a detached protective structure nearby. To increase the survivability of communications, the cables are laid in protective trenches designed for great resistance to dynamic loads in the ground. To disconnect the communications lines at the onset of overvoltage, created by electromagnetic fields from a nuclear explosion, automatic cutoff equipment is provided.

Radio communications are used for the installation when [other] communication lines are put out of commission.

Protected remote control stations are set up to administer production. The construction of these stations, if they are located in detached structures, must ensure the protection of the maintenance personnel and keep the equipment and instruments from being damaged by fragmented pieces of the main building (in which the station is located) if it should be destroyed. To accomplish this, these structures must be properly reinforced.

To administer the off-duty shift in the outlying dispersal area, command posts are established in blast shelters, and if there are no blast shelters, in fallout shelters. Organization of this command post is analogous to that of command post on the site of the installation. The command post in the outer zone is provided with means of communication. The communications unit is located with the command post in a protective structure. Communications with the command structure are achieved by communication lines and radio. The outer-zone command post of an installation may be constructed and equipped with communications facilities under the threat of attack, but to accomplish this, the necessary components must be available in peacetime.

6.4.3 Increasing the Survivability of Buildings and Structures

Destruction of industrial buildings in the majority of cases results in a failure of machinery and communications. A variety of equipment and electronic devices are particularly susceptible to the effects of a nuclear blast. Industrial buildings and structures are built with consideration of the weight and wind loads and are not calculated to resist the damaging effects of a nuclear blast.

Increasing the survivability of buildings and structures may be achieved when planning new construction as well as when rebuilding installations already built or in use. However, these measures are taken only if they are economically feasible.

Increasing the survivability of buildings through basic structural changes involves a great deal of expense and does not yield positive results, since increasing the survivability of individual structures and components cannot guarantee survival from a nuclear detonation. Depending on the [actual] power of the weapon [used] and the [actual] center of the nuclear explosion, the destructive effect of the blast wave may be higher than the limit which was set in the technical engineering design. So taking measures to increase the survivability of individual buildings and their components is practical only (1) when the important individual components of the installation (those on which production depends) are much weaker than the other components or (2) when there is an increase in survivability of those components which could continue production by themselves and turn out products for immediate use. Increasing the survivability of weak individual elements results in the equal survivability of all parts of the facility, as well as in efficiency under a given effect of a nuclear blast.

A study of the nature of the effects of the damaging factors of a nuclear detonation shows that the effects on buildings and structures are not equal. The blast wave, causing damage in varying degrees, and thermal radiation, causing fires, have direct effects on buildings and structures. Initial nuclear radiation and fallout do not have a direct damaging effect on buildings (and structures), but injure persons inside them. Thus, increasing the shielding coefficient and attenuating the harmful effect of radiation on people is very important.

The survivability of buildings and structures in the presence of nuclear detonations increases when their mechanical stability and fire resistance are increased.

1. An increase in the mechanical strength of existing buildings and structures is achieved through appropriate planning as well as through the use of stronger materials and designs giving greater strength. Moreover, various structural solutions are possible. The most important measures for increasing survivability may be putting the building partially underground, or [building it] with a smaller cross-sectional area (a decrease in the area of the walls), and decreasing the height, which greatly increases resistance to the blast wave of a nuclear explosion (Fig. 77).

2. Existing buildings and structures can be reinforced with metal supports and beams to increase their stability. This method is used to increase the survivability of modified basement shelters, as well as the lower stories of buildings on which heavy and cumbersome equipment is located. The use of beams and supports greatly increases the survivability of basements and makes them as strong as a shelter (Fig. 78). Erecting supplementary support columns in single-story plants may be expedient in increasing the survivability of roofs with large spans.

3. Buildings and structures in which expensive equipment is located can be strengthened by the construction of additional walls or structures to withstand the pressure of the blast wave. The walls of buildings can be strengthened with monolithic reinforced concrete slabs.

4. Low structures can be partially covered with earth to increase their survivability. This method of increasing survivability can be used for semi-sunken buildings and various structures (Fig. 79).

5. Tall structures (chimneys, derricks, towers, and columns) can be reinforced with guy wires designed for the load generated by the high-velocity wind of the nuclear blast wave. A ring (for stacks) is mounted as the upper band for the guy wires (Fig. 80).

6. Structures in which easily flammable liquids are stored can be effectively enclosed with an earth embankment. The height of the embankment is determined in accordance with the amount of liquid which would discharge if the vessel were destroyed (Fig. 81).

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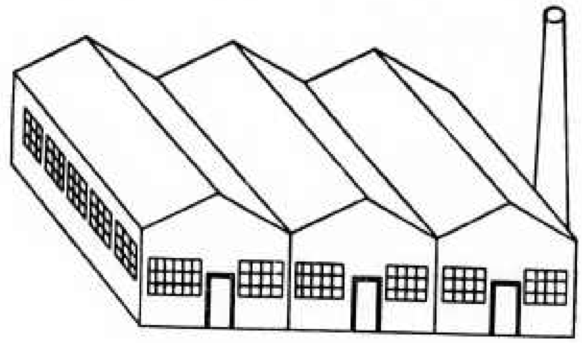

Fig. 77. Overall view of a single-story plant.

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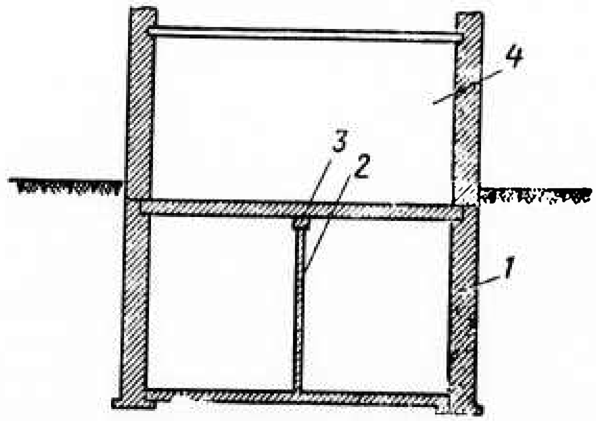

Fig. 78. Reinforcing basement with beams: (1) basement; (2) support; (3) beam; (4) first story.

7. Pipelines of various kinds [that are ordinarily] laid on the surface are advantageously installed underground; this practice increases their survivability five to seven times. It is also possible to lay industrial pipelines and power lines in semi-belowground trenches, thus maintaining all the advantages of aboveground lines and avoiding the disadvantages of underground lines. The survivability of such pipelines is enhanced by covering them with earth when under threat of attack.

8. To protect facilities located in zones of potential catastrophic flooding if hydroelectrical structures are destroyed, it is possible to build dams. These are usually planned during the overall design of the city.

9. Under the threat of enemy attack on plants, equipment and various structures can be covered with sand bags to protect them from damage in a nuclear

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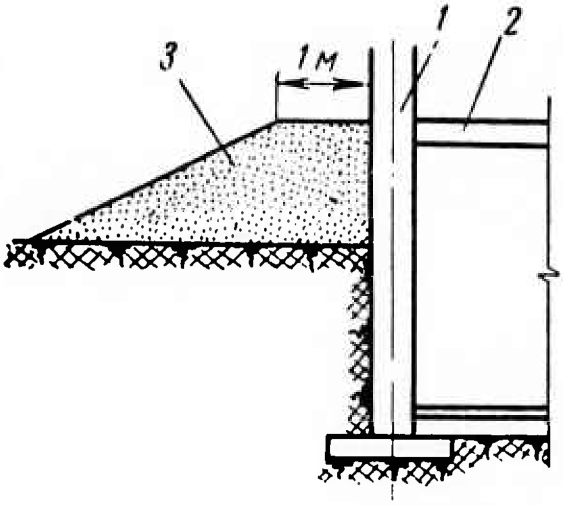

Fig. 79. Shielding a half basement with earth: (1) wall; (2) ceiling; (3) shielding.

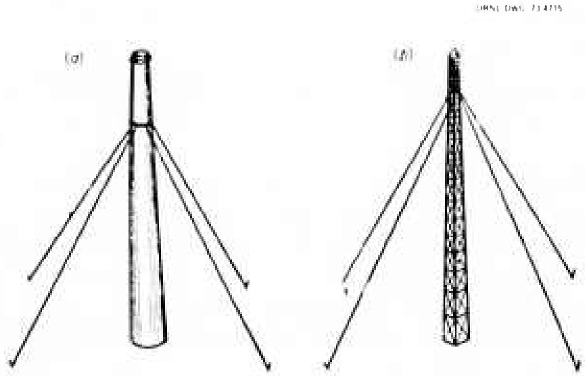

Fig. 80. Reinforcing tall structures with guy wires: (*a*) stack; (*b*) metal tower.

explosion and from falling fragments of destroyed structures.

10. To protect people and equipment, part of the window openings can be blocked with bricks; this procedure increases the survivability of walls and facilitates airtight sealing of the premises. It is also used to increase the survivability of food storehouses, finished-product warehouses, and the like.

Such measures are carried out to decrease the vulnerability only of industrial buildings and special protective shelters. In addition, national economic installations can be built in underground structures.

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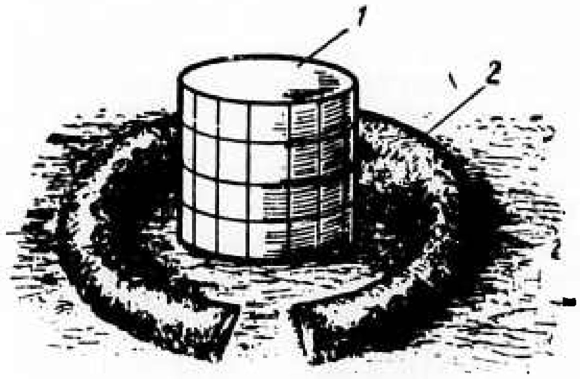

Fig. 81. Structure with earth embankment around liquid fuel tank: (1) liquid fuel tank; (2) earth embankment.

Using natural and artificial underground chambers to house such installations is one of the most effective means of solving the problems of protection against nuclear weapons.

Underground structures were used by Fascist Germany to house industrial plants as early as the Second World War. Near the city of Nordhausen in the Kochstein Hills, old [underground] structures were found which consisted of three parallel, horizontal tunnels about 3 km long. These tunnels were cleared, widened, reinforced, and connected to each other by passageways. Railroad tracks were laid along each tunnel. These tunnels, safe from aircraft, contained a factory producing the FAU-2 rocket.

However, such protection is possible only for individual, particularly important factories and plants; only a fraction of the vast number of plants and industries allocate some units to underground facilities.

To protect buildings and structures from the effects of thermal radiation, it is necessary to increase their resistance to fires. Buildings and structures are made fire resistant by using noncombustible materials in their construction and by satisfying the fireproofing specifications. To increase the fire resistance of existing buildings and structures which are flammable, use fire-retardant paints or use clay as a plaster; wooden structures should be impregnated with fire-resistant compounds (antipyrene). To reduce the probability of buildings and structures catching on fire and to reduce the propagation of fires caused by thermal radiation, a complete system of preventive fireproofing measures is carried out.